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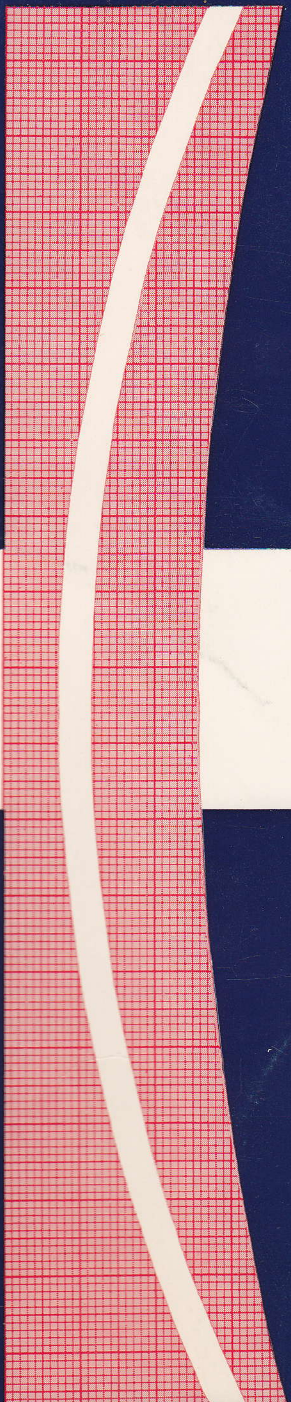

# Optical Precision Measuring Instruments

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# Preface

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This catalogue offers a survey of LEITZ measuring instruments for industrial production control. It briefly describes the function, and gives examples of practical applications and important technical data of each instrument. Separate lists are available for more detailed information and will be supplied on request.

Our production range of precision measuring instruments came into being because we were constantly faced with metrological problems in our own precision-mechanical production departments for which we had to find suitable solutions. The special measuring instruments developed for these purposes were used for quality control in our gauge and tool manufacture and in various production departments for optical precision instruments. Soon they became indispensable, reliable, as well as cost-reducing aids, and we decided to extend these practical methods of optical measurement to other branches of industrial production. LEITZ precision measuring instruments have been constantly developed and improved ever since and are now used in almost every field of technology, mechanical engineering, precision engineering, heavy machine construction, locomotive engineering and shipbuilding, aircraft construction, and in inspection departments and on workbenches.

## Classification

For the execution of technical measurements our precision measuring instruments can be divided into two large groups: –

Linear measuring instruments
Angle measuring instruments

The first group includes instruments for "direct linear measurements" by means of scales, instruments for "differential measurements" by means of gauges and slip gauges, instruments for precise peak-to-valley measurements in surface testing, microscopes for the measurements of Brinell indentations in material testing, as well as telescopes for alignment testing.

Dividing heads, mirror polygons, auto-collimation telescopes and photo-electric incremental angle transducers are instruments for the measurement of angles.

Measuring microscopes and projectors are universal measuring instruments which can be used with equal facility for measuring distances and angles.

Linear and angular measurements can be carried out by purely optical methods or by mechanical tracing. Which method is used depends on the task in hand.

## Optical methods of measurement

Optical paths in microscopes and telescopes permit contactless measurement; in addition they project into infinity vanishing lines which can be combined into an extensive x, y, z coordinate system. The parts to be measured can be freely arranged in any position relative to the beam paths; The setting up of long beam paths involves little or no loss of work space since individuals, hand-carts and even large structural parts can pass through them without interference.

Optical methods allow measurements free from measuring force. This benefits the measuring instruments as well as the parts to be measured by ruling out wear and tear of the measuring media and damage to sensitive surfaces. Measurements, too, are more accurate since the problems of elastic deformation and recovery in instrument and object are avoided.

Optical reproduction free from measuring force is particularly useful in the control of the contours of small parts, and with objects with geometrically complicated measuring surfaces. The optical measuring instrument forms an enlarged shadow image of the object to be measured, e. g. on a screen. Such shadow images can be examined by several persons at the same time. Measurements can be carried out in rectangular and polar coordinates at various reproduction scales. If a given enlargement of an image is insufficient, the next higher enlargement is used, when a fixed, reproducible reproduction scale will again be obtained. Due to the consistent image quality of the objectives the reproduction scale set in our factory remains constant in time. Owing to the telecentric beam path on which we place great value the magnification remains unchanged even if the object does not lie exactly in the focal plane of the objective. Hence, the image can be produced at the same scale even after years, and compared with the drawing.

The versatility of the shadow method will be particularly apparent with the measurement of threads. Here, a single image-producing measuring instrument is sufficient to obtain all the values determining a thread (profile, angle of thread, pitch, outside-, core-, and effective diameter). In addition it is possible to observe during the measurement whether the flank of the thread runs in a straight line, and whether it is rough or smooth.

Generally manipulations can be carried out on the image of a test piece such as a thread, a gear wheel, a plate etc. which would be impossible on the test piece itself. An image can be inverted, projected back onto itself wrong-way-round or upside-down, deflected into another direction, reproduced in colour by means of filters, to mention only a few possibilities.

If the surfaces to be measured have a suitable finish, they can be used as mirrors and be included in the beam path. For this purpose a mark is projected close to the measuring surface and its mirror image used as an optical scanner. In this way the plane or cylindrical measuring surface itself can be scanned instead of the unreliable edge.

A task which can be solved satisfactorily only by optical means is the measurement of alignment and direction in one, two, or three coordinates over long distances. Such measurements are necessary, for instance, in heavy machine and aircraft construction and in shipbuilding. The measuring instruments here are alignment telescopes or autocollimators in conjunction with a small auxiliary system, i. e. a collimating mark or a plane mirror to be placed on the various measuring points. The advantage of optical over mechanical alignment, represented, say, by a length of wire, is its indestructibility, and the fact that it has no material properties making it cumbersome to use.

An extremely low measuring tolerance down to a few $10^{-5}$ mm is achieved with light interferences. Here the light will generally strike the surface of the test piece vertically, and a topographical image of the surface with contour lines is produced by comparison with a second surface, e. g. a plane. The wave length of the light serves as a scale. It determines the vertical distance between the contour lines. Lateral deflections of the contour lines indicate depressions or elevations in the surface.

Line scales can be read reliably to $10^{-4}$ mm with optical aids. A number of measuring instruments therefore combine the advantages of contactless optical scanning with those of optical scale reading. This is carried out either with an eyepiece or on a groundglass screen. Eyepieces are adapted in our works to the normal human eye. Divergences from the correct image position with the eye focused on infinity can be compensated by correction prior to the measurements being carried out.

In many cases eyepieces are replaced by groundglass screens on to which the readings are projected. These have the advantage that the eye is not confined to a certain spot on the instrument, such as an eye-cup. The symmetrical adjustment of the indicator line between double lines, familiar and well-tried in the eyepiece is retained for projection readings in all important cases.

**Optical-mechanical methods of measurement**

Measurement of internal threads and cones, blind bores, counter-bores etc. is impossible with the method of contactless optical scanning. In these cases mechanical tracing is necessary, and the tracing motion must be transmitted by optical-mechanical means. Transmissions based on these structural principles have the advantage of being constant in time. They make use of large lever arms, have little friction and little mass, and with multiple reflections their design is compact.

Measuring instruments with mechanical tracing and optical transmission are also suitable for sensitive difference measurements which require not so much a large as a highly resolved measuring range. With such measurements the measuring force must not be ignored. Its effect is eliminated by settings and measurements in one direction only with the same measuring force. Such optical precision scanning instruments have also been fitted with photo-electric cells for the grading of pointer deflections. They are therefore particularly suitable for serial measurements in which they record the statistical distribution of the measuring values which are automatically transmitted to electric evaluation devices. This application is important for statistical quality control and for classification.

Surface scanning instruments have been developed for the measurement of roughness depth on the principle of the optical precision scanning instrument; from the profile section of the surface they simultaneously reveal the micro- and the macro-geometrical shape of the workpiece under test.

### Precision measuring instruments and their accuracy

Most of the standards of measuring tolerance, reproducibility, and elastic recovery of optical precision measuring instruments to-day exceed the limits of other types of measuring instrument. This enables the optical instruments to satisfy the very stringent requirements of workshop and inspection department which lay down that the accuracy of the measuring instrument should, if possible, be higher by a factor of 10 than the tolerance range of the values to be measured. In addition the image-forming properties of optical components such as lenses and mirrors are not subject to any transient changes. This is a very important point if it is necessary to obtain reproducible values over prolonged periods of work.

The compact design of the optical instruments is particularly advantageous; it not only reduces operational costs, but also gives the user a maximum of certainty and confidence in the values determined.

### The optical precision measuring instrument in workshop and inspection department

As soon as all the questions affecting the choice of a measuring instrument have been settled, the conditions must be created which ensure constant readiness of the instrument and the reproducibility of the measuring results. These two demands can be satisfied provided the following points are observed: –

1) Installation on a rigid support and as free from vibration as possible
2) Protection from dust
3) Avoidance of large temperature variations; avoidance of heat radiation and humidity in the room
4) Maintenance of the standard temperature of 20 °C 68 °F
5) Correct handling and maintenance of the measuring instruments.

The way a measuring instrument is installed may affect its function and measuring accuracy. The precision measuring instrument should be mounted on a rigid table, and large instruments on firm ground in order to prevent changes in inclination, let alone sagging of the instrument during measurements.

Vibrations are eliminated by shock absorbers consisting of plastic sheets for small, and of cork and rubber for large instruments. Their elasticity and damping properties must bear a certain relation to the mass of the instrument.

Temperature has an important effect on the measuring accuracy, since it affects the length of every object. The standard temperature laid down by DIN (German Industrial Standards) 102 for technical measurements is 20 °C (68 °F).

It need hardly be mentioned that LEITZ instruments leave the works only after thorough quality control in perfect condition.

Any individual test records supplied with a LEITZ instrument are essential components of this instrument and should be kept in the department processing the measuring values.

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# 1.

# Optical linear and angle measurement with measuring microscopes

Measurements which are essential for the correct functioning of an instrument must be accurately controlled; however, a large variety of objects cannot be measured by mechanical tracing. Thread profiles, profile gauges, and cutting tools are suitable for optical methods, i. e. microscopic sighting, only.

Microscopes are used with machine tools such as profile grinders etc., to allow the comparison of the workpiece with a profile drawing inserted in the microscope; alternatively, with built-in graticules they simplify the setting of workpieces or tools.

Microscopes which permit the **measurement** of a testpiece have more versatile applications. The following methods can be used: –

1) Measurement of the testpiece with a micrometer eyepiece

2) Measurement by moving the microscope tube, or the testpiece with the aid of a measuring stage.

The first method is used for small objects because the field of view of a measuring eyepiece is relatively small.

The second group includes a large number of measuring microscopes based on various principles of design, and of various sizes. The simplest instruments are measuring microscopes with tube displacement, measuring in one coordinate only. The tube is adjusted with measuring spindles, and the measuring value read off linear or drum scales. If measuring stages are used, coordinate measurements can be carried out even with instruments incorporating fixed tubes. Measuring stages, too, are fitted with measuring spindles and measuring -drums; scales with microscopic – or projection – reading are used where extremely small measuring tolerances are essential.

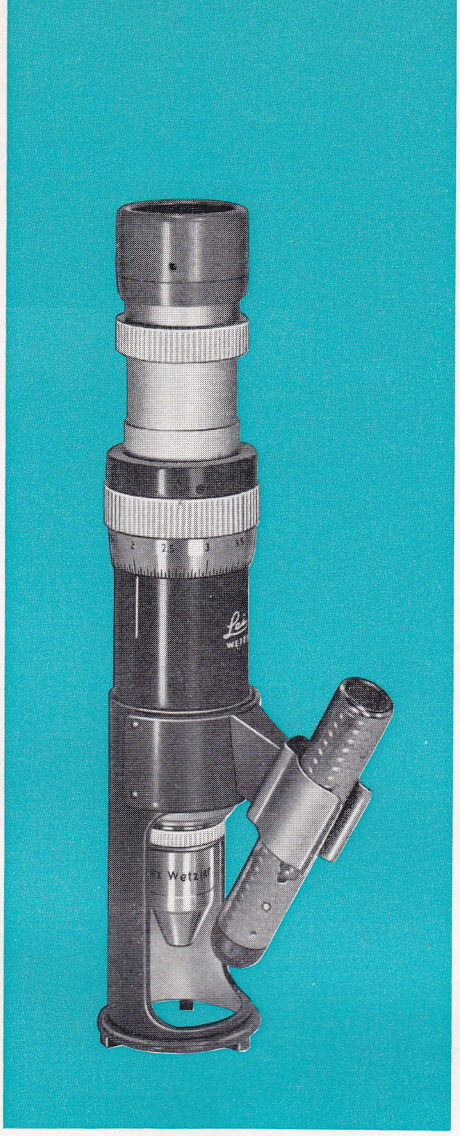
Our measuring microscopes are designed and classified to satisfy the conditions of the required measuring tolerances.

In many cases devices for the illumination of the objects to be measured in transmitted- and incident light are available.

The design of the microscope tubes has been adapted to suit the widely varying measuring tasks. They are usually fitted with interchangeable eyepieces with changing device, interchangeable or sliding or revolving objectives for changing the magnification, and a graticule turret. In our measuring tubes the graticules – with drawings of standardized thread profiles, angle marks, tooth shapes, radii, and special profiles – are mounted in so-called intermediate image planes. Wherever possible the object to be measured is projected at natural size in the intermediate image plane, and subsequently magnified by the objective and eyepiece **together** with the profile of the graticule. Errors of distortion cannot occur with such optical systems.

The avoidance of errors not only of distortion, but also of magnification is of considerable importance. If the viewer does not focus accurately the object to be measured the reproduction ratio will be changed in a normal microscope even within the depth-of-field zone, since the rays emitted by the out-of-focus object points are inclined to the optical axis, thereby causing an error of magnification. In order to avoid this, the so-called telecentric ray system is used with the aid of a special objective and a stop. With such an arrangement the unavoidable focusing inaccuracies do not change the reproduction ratio (for explanation see p. 43).

# Measuring microscope for engraving and scratch depths



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### Examples of uses

Measurement of the depth of engravings,
the depth and width of scratches, etchings, etc.

### Technical data

| | | | |
|---|---|---|---|
| **Magnification** | **50** | **x** | |
| **Object field diameter** | **4.5** | **mm** | **0.18″** |
| **Aperture** | **0.1** | | |
| **Depth measuring range** | **9** | **mm** | **0.36″** |
| **Scale unit for depth measurements** | **0.05** | **mm** | |
| **Linear measuring range** | **3.5** | **mm** | **0.14″** |
| **Scale unit for linear measurements** | **0.025** | **mm** | **0.001″** |
| **Weight** | **approx. 0.3** | **kg** | **0.66 lbs.** |

### Description

This microscope is a special variant of our measuring microscope MZ (p. 56); its stand has an additional measuring device for the vertical displacement of the microscope tube.

With depth measurements, the surface is focused first, and the bottom of, e.g., the engraving second. The depth is the difference between the setting values read off a scale. Widths of scratches can be measured with the graticule built into the eyepiece. The foot of the stand with its prismatic recess can be placed on curved or plane objects for measurement. A battery- or mains-operated lighting attachment is available for illuminating the field of view.

# Measuring microscope TBS 50

### Examples of uses

Technical linear measurements up to 50 mm; e. g. measurements of scales, line gauges, Brinell indentations, bore diameters and distances.

### Technical data

| | | | | | | |
|---|---|---|---|---|---|---|
| Measuring range | 50 mm | 2″ | | | | |
| Scale unit | 10 µm | 0.0001″ | | | | |
| **Tube I** | | | | | | |
| Total magnification | approx. 35 x | | | | | |
| Object field diameter | 3.5 mm | 0.14″ | | | | |
| Aperture | 0.15 | | | | | |
| Working distance | approx. 27 mm | 1.06″ | | | | |
| **Tube II** | | | | | | |
| Total magnification | 10 x | | 20 x | | 30 x | |
| Object field diameter | 20 mm | 0.79″ | 10 mm | 0.39″ | 6.5 mm | 0.26″ |
| Aperture | 0.066 | | 0.075 | | 0.08 | |
| Working distance | 100 mm | 4″ | 75 mm | 3″ | 54 mm | 2.1″ |
| Height x width x depth | 400 x 200 x 300 mm | 16 x 8 x 12″ | | | | |
| Weight | approx. 23 kg | 50 lbs. | | | | |

### Description

The upright of the sturdy stand carries a vertically adjustable horizontal guide in which the measuring tube is moved on a ball race free from play by means of a micrometer spindle. For rapid adjustment over a large range the threaded nut can be disengaged by means of a lever. The millimetre (inch) values are read off a scale (scale unit 1mm [0.4″]), the fractions off the prominent scale drum division (scale unit 10 µm [0.0001″]).

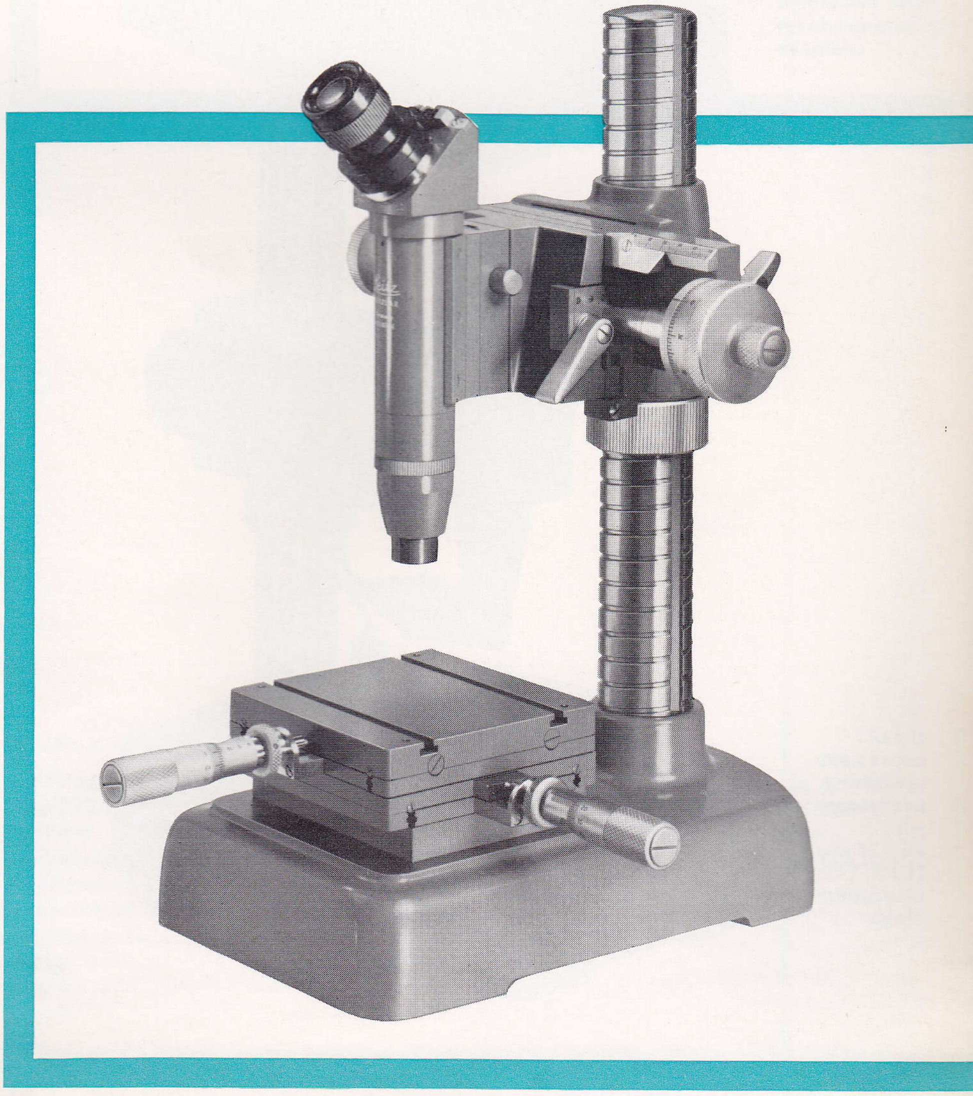
The stand can be equipped with transmitted-light illumination on request.

Two types of tube are available according to requirements: –

Tube I: Inclined viewing; eyepiece with cross lines and focusing eyelens; attachable incident-light illumination.

Tube II: Inclined viewing; upright image; interchangeable objectives for changing the magnification, and interchangeable measuring eyepieces; incident-light attachment; angle measurements possible with the aid of goniometer eyepieces.

Detailed description: – List No. 81 – 15.



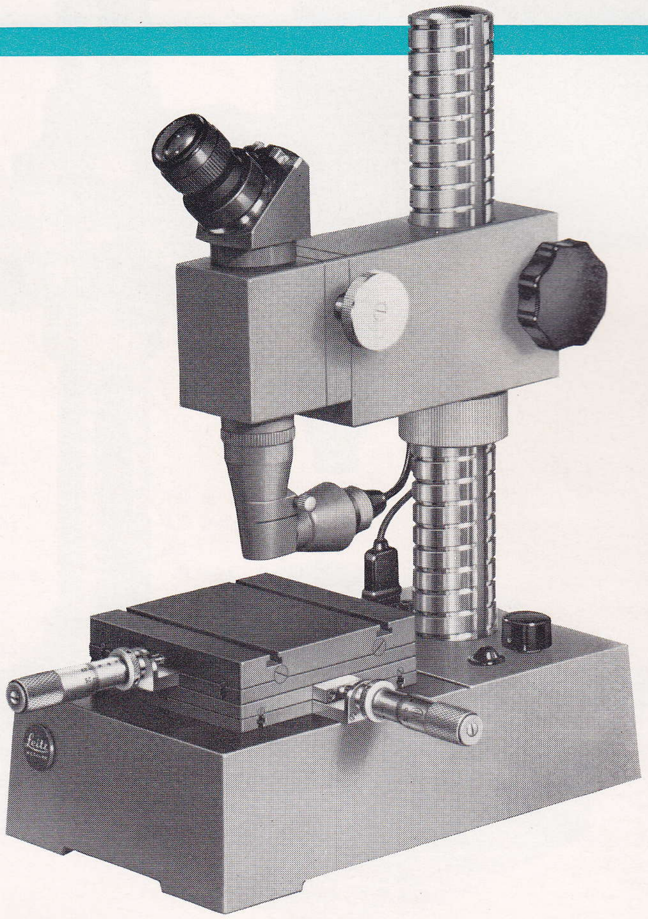
# Small coordinate measuring microscope

### Technical data

| | | | |
|---|---|---|---|
| Total magnification | 10 x | 20 x | 30 x |
| Object field diameter | 20 mm 0.79″ | 10 mm 0.39″ | 6.5 mm 0.26″ |
| Aperture | 0.066 | 0.075 | 0.08 |
| Working distance | 100 mm 4″ | 75 mm 3″ | 54 mm 2.1″ |
| Measuring ranges of the stage | 25 x 25 mm or 50 x 50 mm 1 x 1″ or 2 x 2″ | | |
| Scale unit of the measuring drums | 10 $\mu$m 0.0005″ | | |
| Height x width x depth | 450 x 450 x 400 mm 18 x 18 x 16″ | | |
| Weight | approx. 23 kg 50 lbs. | | |

### Examples of uses

Measurements of small objects in watchmaking, electrical engineering, instrument building, valve manufacture, etc.



Small coordinate measuring microscope with 25 x 25 mm (1 x 1″) measuring stage

### Description

Design and accessory range of the coordinate measuring microscope make this instrument particularly well suited for the inspection of small parts.

A low-voltage unit is available for transmitted-light illumination. Incident-light sources can be directly mounted on the tube.

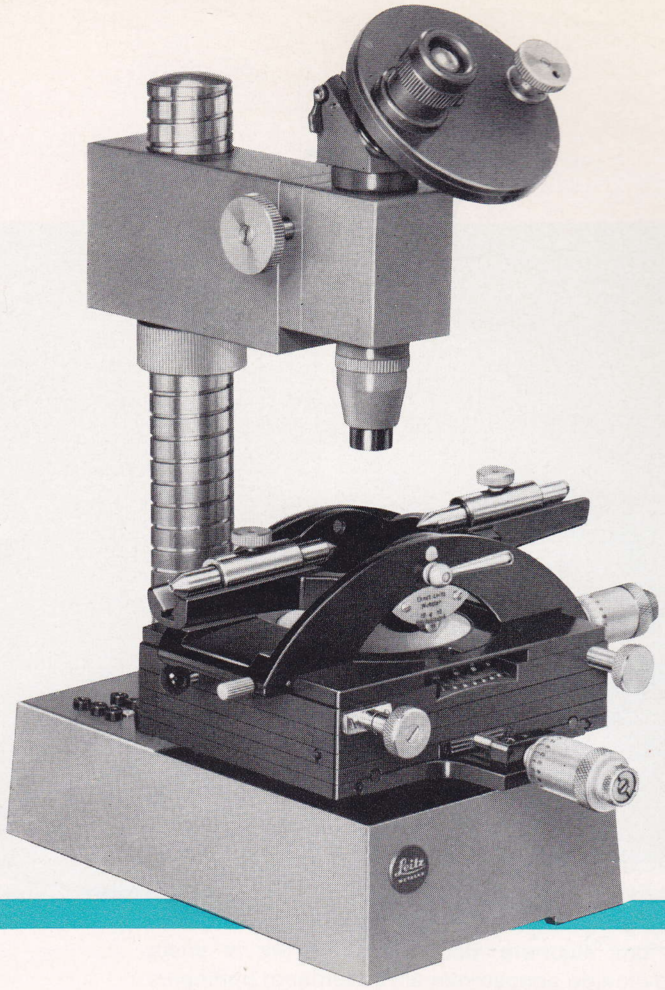
In addition to the measuring stage normally supplied, which has measuring range of 25 x 25 mm (1 x 1″), a stage with a 50 x 50 mm (2 x 2″) range is available (p. 26). The latter can be fitted with a built-in rotating stage (p. 26).

The tube which is vertically adjustable by rack-and-pinion drive is designed for use with various eyepieces for linear and angle measurements.

The following eyepieces can be inserted: –

Coordinate screw micrometer eyepiece for precision measurements (p. 25), goniometer eyepiece for angle measurements (p. 24), eyepiece with built-in rotating graticule with a set of concentric circles, thread profiles, and cross lines.

# Profile measuring microscope



Measuring microscope for profile measurements with center cradle and with revolving-graticule eyepiece

### Examples of uses

Coordinate measurements, inspection of threads, formtools, profile gauges etc.

### Description

In addition to pure coordinate and angle measurements this measuring microscope permits the inspection of threads in profile section. For this purpose it is fitted with a tilting center cradle..

The instrument is equipped with transmitted-light illumination; an incident-light source can be attached if necessary.

The objectives for a total magnification of 10x, 20x, 30x are interchangeable. For angle measurements the goniometer eyepiece (p. 24), and for thread and coordinate measurements a revolving-graticule eyepiece with a selection of graticules are available.

Besides the 50x50 mm (2x2″) measuring stage with built-in rotating stage shown here the measuring stages described on pp. 26 and 27 can be used.

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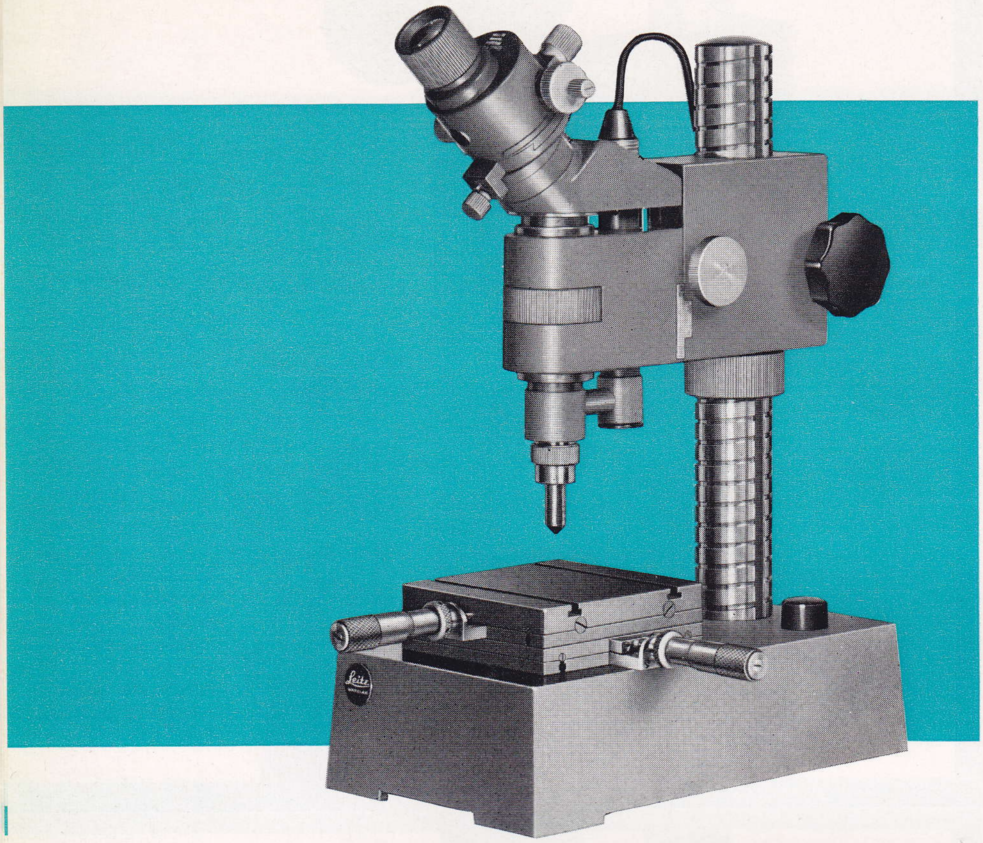
### Technical data

| | | | |
|---|---|---|---|
| Total magnification | 10 x | 20 x | 30 x |
| Object field diameter | 20 mm 0.79″ | 10 mm 0.39″ | 6.5 mm 0.26″ |
| Aperture | 0.066 | 0.075 | 0.08 |
| Working distance | 100 mm 4″ | 75 mm 3″ | 54 mm 2.1″ |
| Measuring range of the stage | 50 x 50 mm | 2 x 2″ | |
| Scale unit of the measuring drums | 10 μm | 0.0005″ | |
| Rotating range | 360 ° | | |
| Vernier reading | 2 min. | | |
| Height x width x depth | 415 x 180 x 290 mm | (16.3 x 7.1 x 11.4″) | |
| Weight | approx. 23 kg | 50 lbs. | |

# Precision measuring microscope



### Examples of uses

Linear measurements on small precision parts, or of short measuring distances, e. g. engravings, hardness indentations.

### Description

The most outstanding feature of the precision measuring microscope is its ability to measure even under high magnifications so that the most minute distances can be determined.

For changing the magnification, the objectives can either be individually interchanged, or mounted on a revolving nosepiece (triple or quadruple). The measuring eyepieces provided for 200 x and 400 x total magnification permit the reading of the measuring value in the field of view (internal reading).

A fine adjustment built into the microscope makes accurate focusing of the object to be measured possible even at the smallest depth of field.

The basic outfit of the instrument is equipped with incident light. Transmitted-light illumination can be installed for the 50 x total magnification.

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### Technical data

| Total magnification | 50 x | 100 x | 200 x | 400 x | 600 x |
|---|---|---|---|---|---|
| Aperture | 0.09 | 0.18 | 0.35 (0.2)* | 0.7 (0.5)* | 0.95 |
| Object field diameter | 3.6 mm 0.14″ | 1.8 mm 0.07″ | 0.9 (0.9) mm* 0.035″ (0.035″)* | 0.45 (0.45) mm* 0.017″ (0.017″)* | 0.3 mm 0.012″ |
| Working distance | 12.5 mm 0.49″ | 12.7 mm 0.5″ | 0.9 (24) mm* 0.035″ (0.95″)* | 0.2 (3.3) mm* 0.008″ (0.13″)* | 0.1 mm 0.004″ |
| Eyepiece measuring range | | | 0.5 mm 0.02″ | 0.25 mm 0.01″ | |
| Scale unit | | | 1 µm 0.00005″ | 0.5 µm 0.000025″ | |
| Height x width x depth | 500 x 270 x 400 mm | 20 x 10.5 x 16″ | | | |
| Weight | approx. 19 kg | 42 lbs. | | | |

* The values in brackets refer to special objectives with large working distances

# Toolmakers' microscope WM

## Technical data

| | | | |
|---|---|---|---|
| Total magnification | 9.5 x | 20 x | 29 x |
| Object field diameter | 20 mm 0.79″ | 10 mm 0.39″ | 6.5 mm 0.26″ |
| Aperture | 0.04 | 0.04 | 0.04 |
| Working distance | 75 mm 3″ | 75 mm 3″ | 75 mm 3″ |

| | | | |
|---|---|---|---|
| Measuring range of the stage | | | |
| longitudinal | 100 | mm * | 4″ * |
| transverse | 25 | mm ** | 1″ ** |
| Scale unit of the measuring drums | 5 | µm | 0.0001″ |
| Height x width x depth | 600 x 500 x 750 | mm | 24 x 20 x 30″ |
| Weight | approx. 40 | kg | 88 lbs. |

* 25 mm (1″) with measuring spindle, 75 mm (3″) with slip gauges
** with center cradle for measuring range expansion 75 mm (3″)

## Examples of uses

Inspection and measurement of threads, profile gauges, form-tools, milling cutters, cutting tools etc. in workshop and inspection department.

## Description

The graticule tube of the toolmakers' microscope which can be tilted for thread measurements, carries a turret with 8 built-in graticules (tabulated in our List 80—3), and a changing chamber for the insertion of further graticules or small comparison objects. The graticules are introduced into the field of view of the microscope by rotating the turret.

Extremely precise profile control is achieved by the telecentric intermediate image system built into the lower part of the tube. It projects a 1 : 1 image of the test-piece in the plane of the graticules. Both graticule and test piece are magnified together by the microscope objective and eyepiece. This allows any change in the magnification using the same graticules and the employment of comparison objects for control purposes.

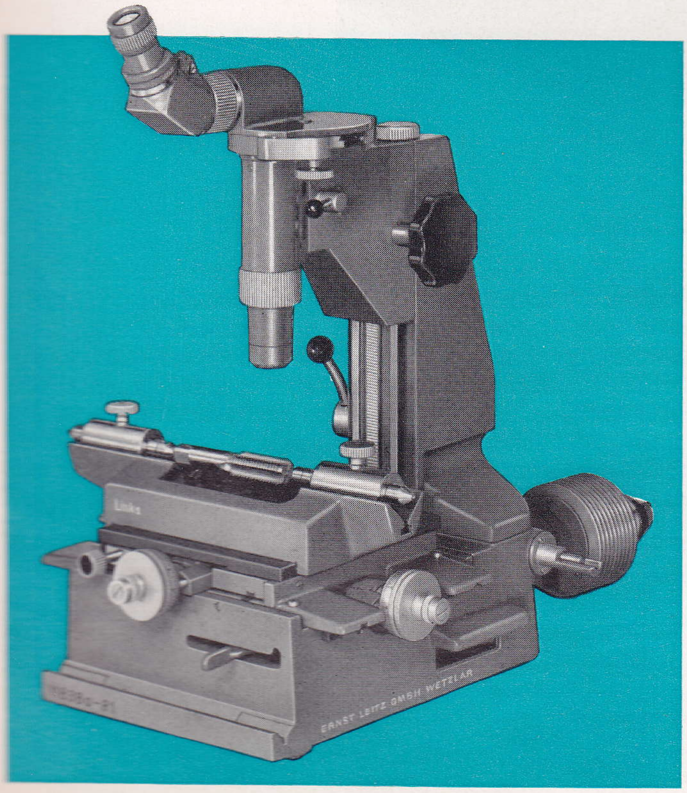
According to the task in hand the graticule tube can be interchanged against other tubes and attachments such as the simple measuring tube, simple graticule tube, double-image tube (p. 24), light-section attachment (p. 23), and optical zero indicator (p. 21).

The measuring stage, designed for measurements in right-angle coordinates, moves on rollers in ground prismatic tracks. Rotating stages with vernier or optical scales* for angle measurements, and center cradles with or without measuring range extension for the clamping of round parts can be mounted on it.

The toolmakers' microscope is fitted with transmitted-light illumination; incident-light illumination can be attached.

* Optical rotating stage p. 27.

Detailed description: — List 81 — 1.



# Large toolmakers' microscope UWM

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## Technical data

| Monocular graticule tube * | | | |
|---|---|---|---|
| Total magnification | 10 x | 20 x | 30 x |
| Object field diameter | 20 mm** 0.79″ ** | 10 mm 0.39″ | 6.5 mm 0.26″ |
| Aperture | 0.06 | 0.06 | 0.06 |
| Working distance | 78 mm 3.1″ | 78 mm 3.1″ | 78 mm 3.1″ |

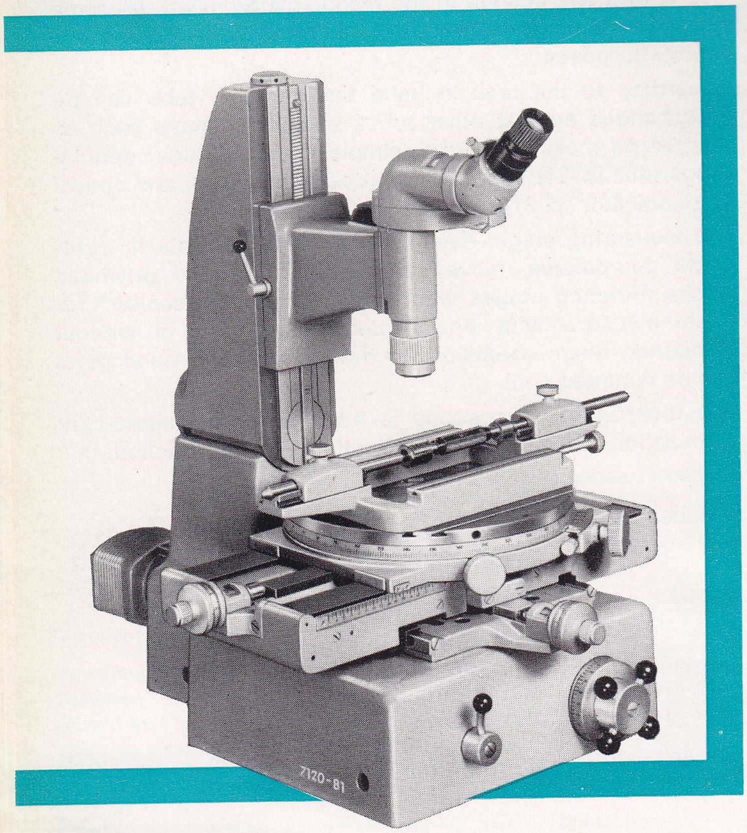
| | | | |
|---|---|---|---|
| **Projection measuring stage** | | | |
| Measuring range | 200 x 75 | mm | 8 x 3″ |
| Stage mounting surface | 400 x 250 | mm | 16 x 10″ |
| Scale unit of the projection scale | 5 | µm | 0.0001″ |
| **Stand** | | | |
| Tilting range of the upright | ± 10 | ° | |
| Distance Optical axis – Upright | 180 | mm | 7″ |
| Height x width x depth | 900 x 650 x 900 | mm | 36 x 26 x 36″ |
| Weight | approx. 140 | kg | 310 lbs. |

* see also binocular measuring tube p. 20.

** 16 mm when a graticule is used.

## Examples of uses

For testing and measuring pitch,
core-, effective-, and outside diameters
of external and internal threads,
inside cones, threading tools,
profile gauges, profile cutters, formtools,
stamped metal parts and pressings,
gear wheels, hobs, etc.



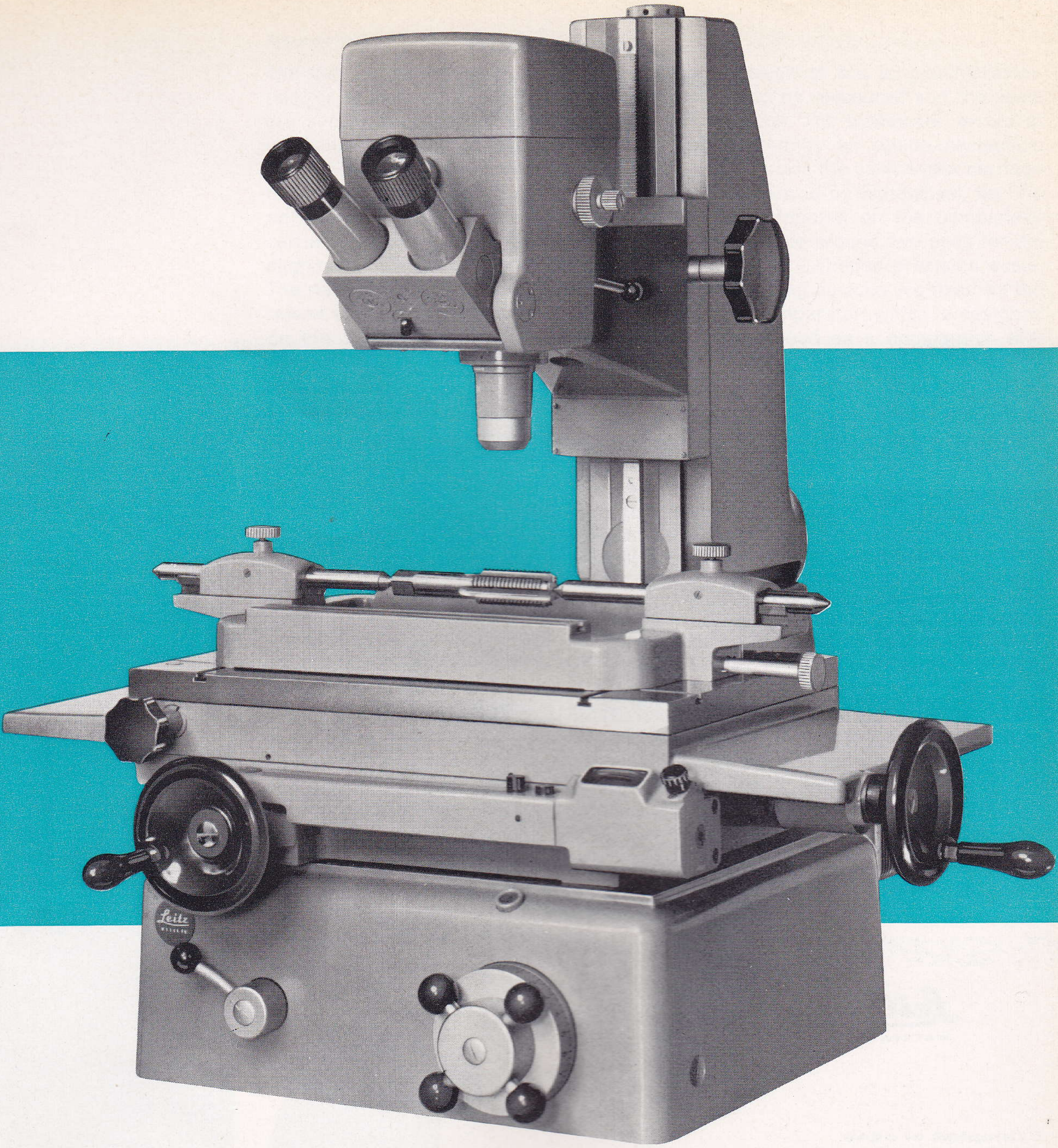
UWM with monocular measuring tube and mechanical measuring stage

## Description

The UWM is a further development of our well-tried Toolmakers' Microscope WM. Although the special design features have been retained – upright and right-way-round image, telecentric beam path, and 1 : 1 intermediate image – this microscope has an extended measuring range; with a monocular or binocular measuring tube, and accessories such as the optical zero indicator (p. 21), the internal measuring device (p. 22) etc. it can be equipped so universally that it will replace several measuring instruments.

A mechanical or a projection measuring stage can be mounted on the robust stand.

The mechanical measuring stage (p. 28) can be adjusted longitudinally and transversely with measuring spindles and slip gauges – range 150 x 60 mm (6 x 2.36″). A built-in rotating



**UWM with binocular measuring tube and projection measuring stage**

stage allows angle measurements of 360° with vernier readings to 2 min.

The projection measuring stage is equipped with glass scales in both coordinates, to be read by means of a projection device. Center cradles and the optical rotating stage (p. 27) can be mounted on the tilting stage plate.

The basic construction of the monocular tube with graticule turret corresponds with that of the toolmakers' microscope WM. In addition it has an objective revolver for direct change of magnification.

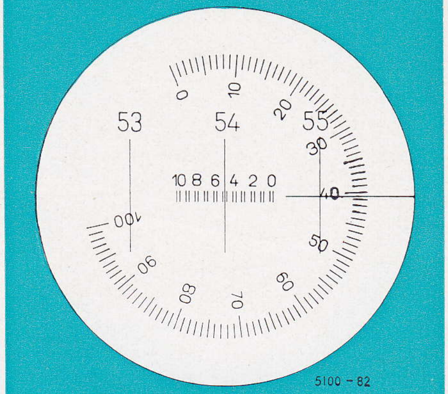
The binocular measuring tube (p. 20) also forms an upright and right-way-round image and through binocular viewing eliminates eyestrain even during prolonged measurements.

Detailed description: — List 81—10.

# Universal
# COMPARATOR
# 200

**Technical data**

| | | | |
|---|---|---|---|
| Measuring range | 200 | mm | 8″ |
| Total magnification of the reading microscope | 50 | x | |
| Scale unit of the micrometer eyepiece | 1 | μm | 0.00005″ |
| Maximum height of the objects to be measured by centre measurement with the perflectometer | 60 | mm | 2.4″ |
| Total magnification of the perflectometer | 34 | x | |



View of the micrometer eyepiece; value read: $54.540^5$ mm

COMPARATOR 200
with perflectometer

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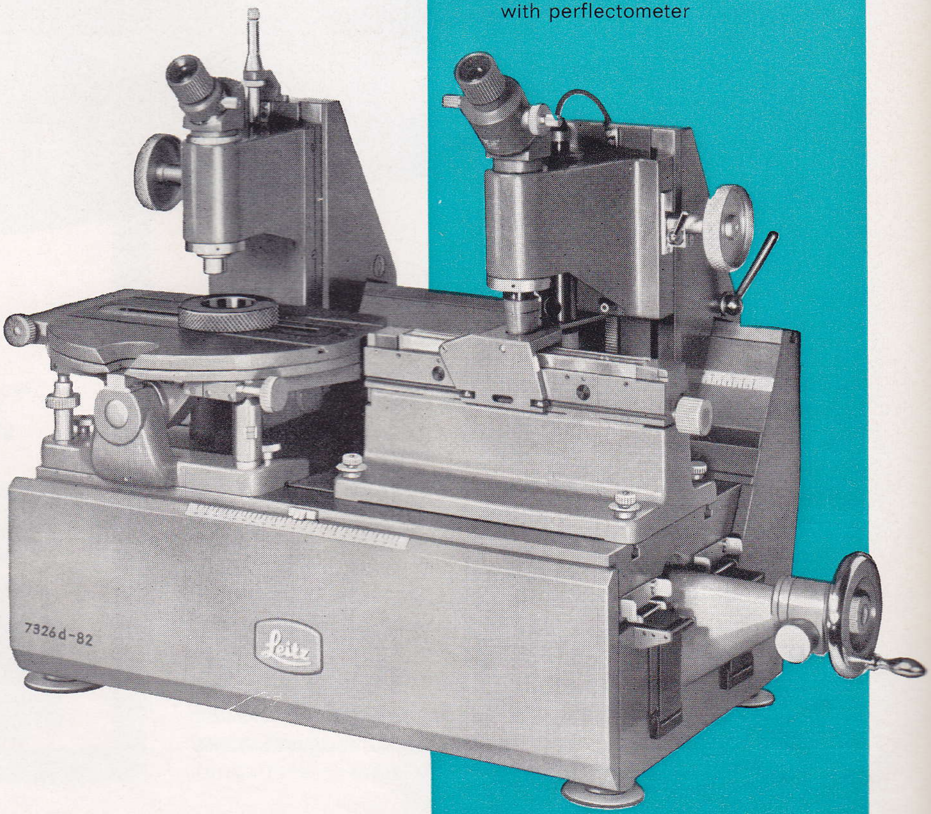
**Examples of uses**

Linear measurement
of slip gauges,
flat gauges,
snap gauges,
ring gauges,
line standards,
internal thread gauge rings,
taper sleeves, etc.

Measurement of changes in length
of concrete,
cement,
refractory materials,
road surfaces
and other materials.



## Description

The comparator principle has been used in the design of this longitudinal comparator. According to Abbe's Principle, the object to be measured and the scale are successively arranged in the measuring direction. The systematic errors of graduation present in every scale are compensated by an optico-mechanical device. The distortion-resistant cast angular base supports the comparator carriage on the horizontal ground tracks. Its coarse adjustment is by handwheel, its fine adjustment by helical drive and a knurled knob. Mounted on the comparator carriage are the clamping stage, rotatable and inclinable around two axes for the alignment of the workpiece, and the mount for the H – shaped precision scale. The riders for the measuring and for the optical scanning devices are fixed on the raised side of the cast angular base. The universal comparator, which is designed on the construction-set principle, can thus be equipped as a comparator with perflectometer, as a linear comparator with focusing microscope, and as an extensometer.

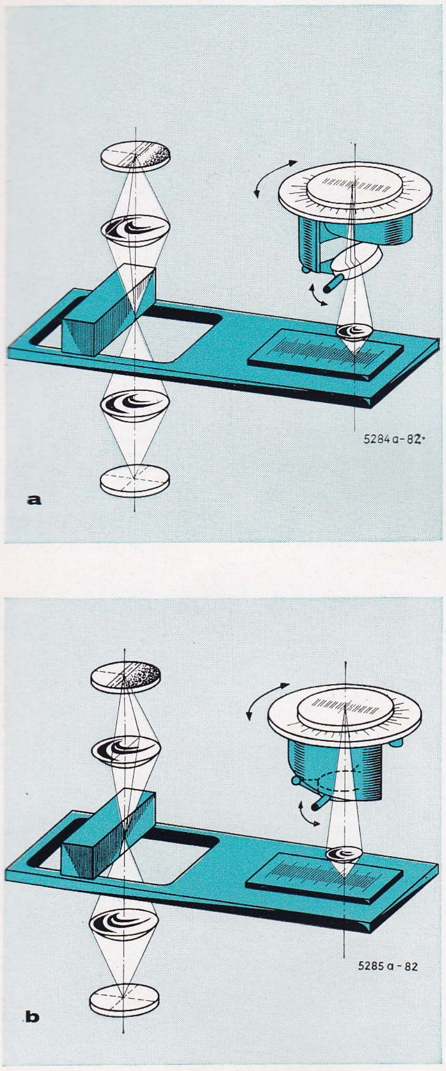
The perflectometer consists of two microscopes facing each other. The microscope mounted below the clamping stage projects cross lines into the measuring plane. A measuring surface aligned parallel to the optical axis reflects this cross line image into the eyepiece of the upper microscope which with its double lines allows accurate setting of the cross line image. Even measuring surfaces which appear almost matt can be scanned perfectly with the perflectometer. The comparator scale is read by means of an incident-light microscope with a micrometer eyepiece permitting direct readings to 1 $\mu$m; fractions can be estimated without difficulty.

The difference between the comparator with perflectometer and the linear comparator consists of a simple focusing microscope which in the latter replaces the perflectometer. With linear measurements, e. g. of line standards, the scale line is set microscopically.

The extensometer version is equipped with the focusing microscope of the linear comparator and a reading microscope with screw micrometer eyepiece. A 160 mm (6.4″) glass scale is used for the setting and control of the two microscopes. The extensometer permits the measurement of changes in length of concrete, cement, refractory materials, etc.

The internal measuring device (p. 22) is supplied; for the measurement of bores, taper sleeves, internal threads etc. For the measurement of concealed measuring surfaces the optical zero indicator (p. 21) is available. Both attachments can be used in place of the perflectometer.

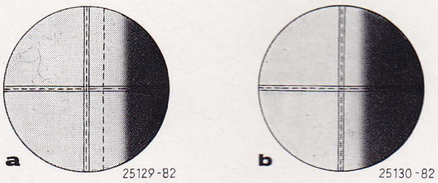
Detailed description: List 82–9.



Function of the comparator with perflectometer (on the left perflectometer and object of measurement, on the right micrometer eyepiece and scale).

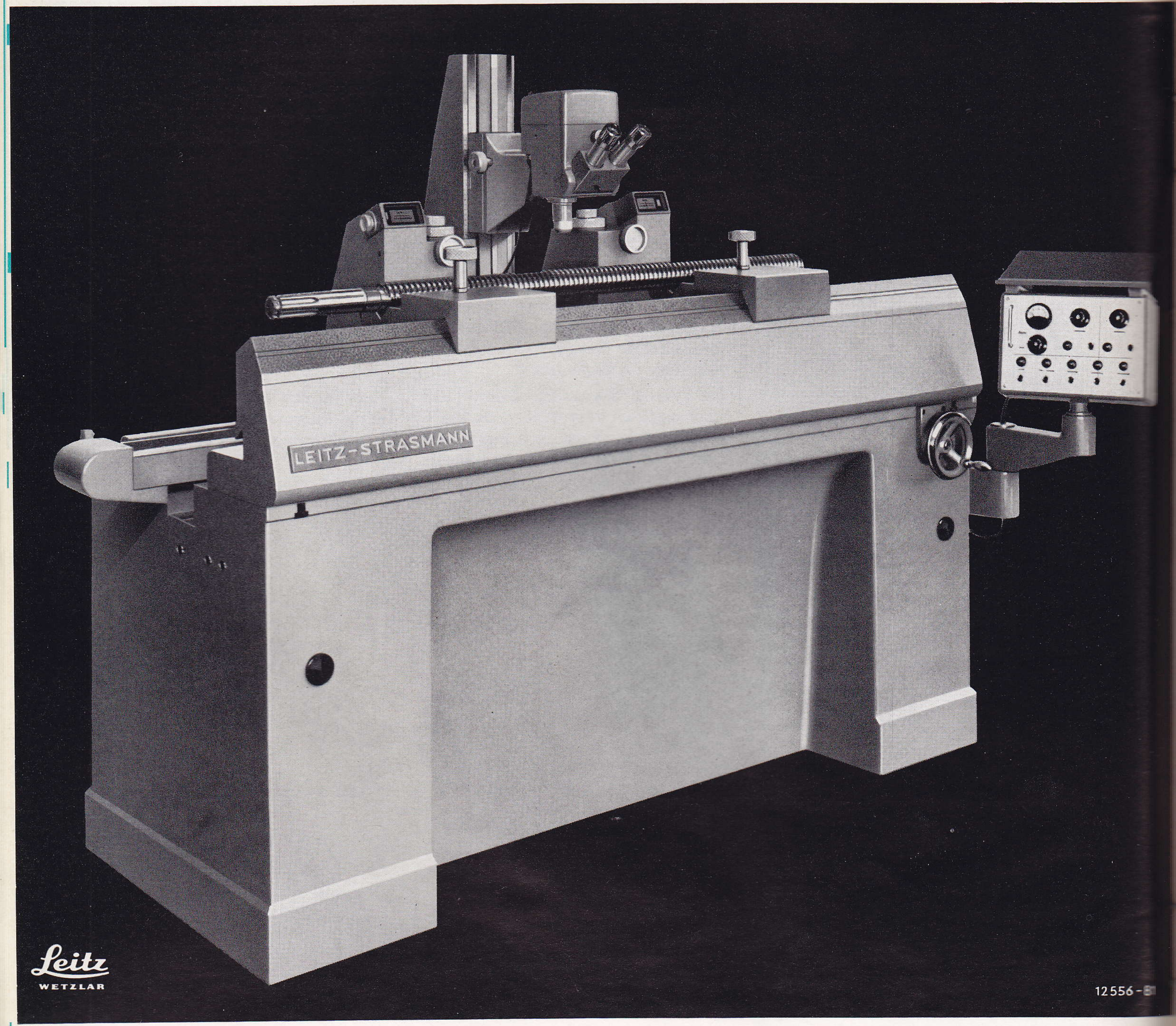
**a**
reflected cross lines before setting;

**b**
reflected cross lines have been set; the value of the first setting can be read after the setting in the micrometer eyepiece of the scale division shown as final in this illustration.



Field of view of perflectometer eyepiece

# Leitz-Strasmann universal measuring machine



### Examples of uses

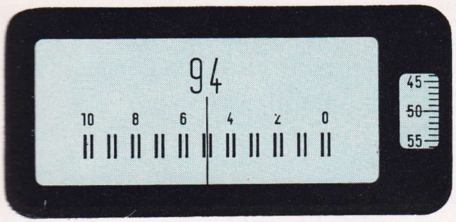
For the measurement of large and bulky parts which cannot be accommodated by measuring microscopes; — thread gauges, threaded spindles, lead screws, profile cutters, wormgears, gearboxes, jigs, etc.

### Technical data

| | | | |
|---|---|---|---|
| **Measuring range of the longitudinal adjustment *** | **1000** | **mm** | **40″** |
| **Measuring range of the transverse adjustment** | **200** | **mm** | **8″** |
| **Divided and numbered scale division** | **1** | **mm** | **0.05″** |
| **Scale unit of the projection scale** | **1** | **μm** | **0.00005″** |
| **Maximum distance between centers** | **1100** | **mm** | **41″** |
| **Maximum clamping diameter between centers** | **250** | **mm** | **10″** |

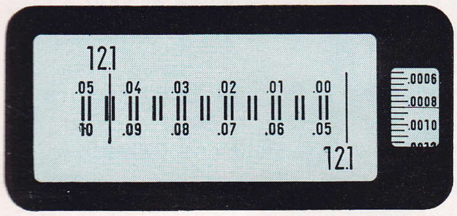
| | | | |
|---|---|---|---|
| **Stage mounting surface** | **420 x 120** | **mm** | **16.5 x 4.7″** |
| **Binocular measuring tube (p. 20)** | | | |
| **Monocular measuring tube (p. 12)** | | | |
| **Height x width x depth** | **1250 x 1950 x 850** | **mm** | **50 x 77 x 33.5″** |
| **Weight** | **approx. 1700** | **kg** | **3700 lbs.** |

* on request 2000 mm (80″)



6381-87

Scale image with projected reading (metric);
value read: 94.550 mm



25016-87

Scale image with projected reading (English);
value read: 12.14585″

### Description

The design of the universal measuring machine combines the dimensions and robustness of a machine tool with the metrological properties of an optical precision measuring instrument. It has been constructed so that the object is stationary while the optical measuring device is adjusted during measurement; hence, the measuring proceeds with the minimum possible weight displacement.

The angle-shaped workpiece carrier is mounted on the front of the sturdy base. It can be tilted by means of a handwheel for the alignment of the workpieces. Center cradles, V-blocks, and a clamping stage are available for fixing the objects to be measured. For measuring the pitch of hobs, tumbling errors of threads, etc. an optical index plate with fine adjustment can be attached to the left-hand rider. The angle values are optically divided and read to units of 5 secs. on a groundglass screen (projection window). The longitudinal and the transverse measuring slides are mounted on the base behind the stage. Both slides move on rollers and can be easily adjusted in spite of their heavy weight. Precision scales combined with prominent projection windows serve for measurements in both directions. For the scanning and observation of the object to be measured tubes and attachments such as the monocular graticule tube, binocular measuring tube (p. 20), perflectometer (p. 15), internal measuring device (p. 22), optical zero indicator (p. 21) etc. can be attached to the large upright. These accessories make the measuring machine so universal that it will be equal to almost all the tasks likely to occur in metrology.

The instrument can be operated from a sitting or a standing position. All operating points and switch buttons for transmitted and incident light illumination are prominently arranged and easily accessible.

Detailed description: — List 81—3.

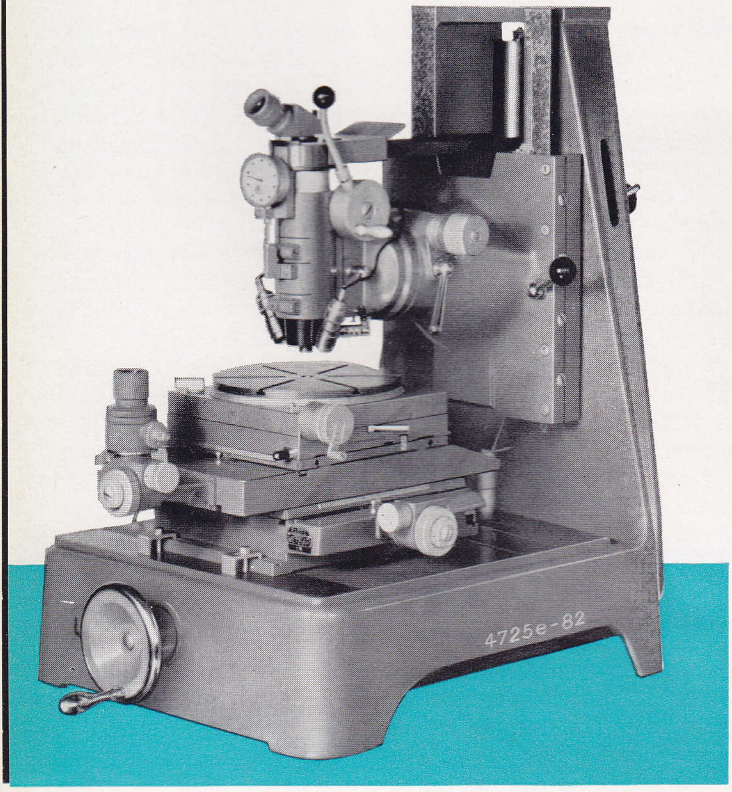
# Precision jig borer KB 150

### Technical data

| | | | |
|---|---|---|---|
| Adjustment range of the stage | 150 x 150 | mm | 6 x 6″ |
| Scale unit | 1 | $\mu$m | 0.00005″ |
| Angle division | 0 . . . 360 | ° | |
| Vernier reading | 10 | sec. | |
| Clamping surface diameter | 205 | mm ⌀ | 8.1″ |
| Microscope | | | |
| Total magnification | approx. 25 | x | |
| Object field diameter | 3.5 | mm | 0.14″ |
| Boring ranges | | | |
| Maximum bore diameter | 3 | mm | 0.12″ |
| Maximum turn-out diameter | 12 | mm | 0.47″ |
| Height x width x depth | 750 x 1000 x 500 | mm | 30 x 40 x 20″ |
| Weight | approx. 250 | kg | 550 lbs. |

### Examples of uses

Jig borer and measuring microscope for precision engineering.
For center-punching, drilling, turning out and subsequent inspection of workpieces at a single setting.



### Description

The jig borer is fitted with a coordinate measuring stage with built-in precision scales which are read with a micrometer eyepiece; setting errors caused by mechanical transmission elements are therefore excluded. Since the measuring stage is combined with a rotating stage it is also possible to work and measure in polar coordinates.

A microscope is built into the boring spindle. It is adjusted so that the axes of sight and of rotation coincide exactly. Cross lines with several concentric circles serve for locating the workpiece.

The boring tools are mounted in the spindle which runs on special ball bearings, either directly, or with a collet. Reduction gears give a choice of 700, 1800, and 4000 r. p. m.

If the jig borer is to be used as a coordinate measuring microscope the boring spindle must be replaced by a measuring tube (magnifications 10 x, 20 x, 30 x).

The eyepiece of the measuring tube contains a cross line graticule. Other graticules can be built in on request. For angle measurements the standard eyepiece can be replaced by a goniometer eyepiece (p. 24).

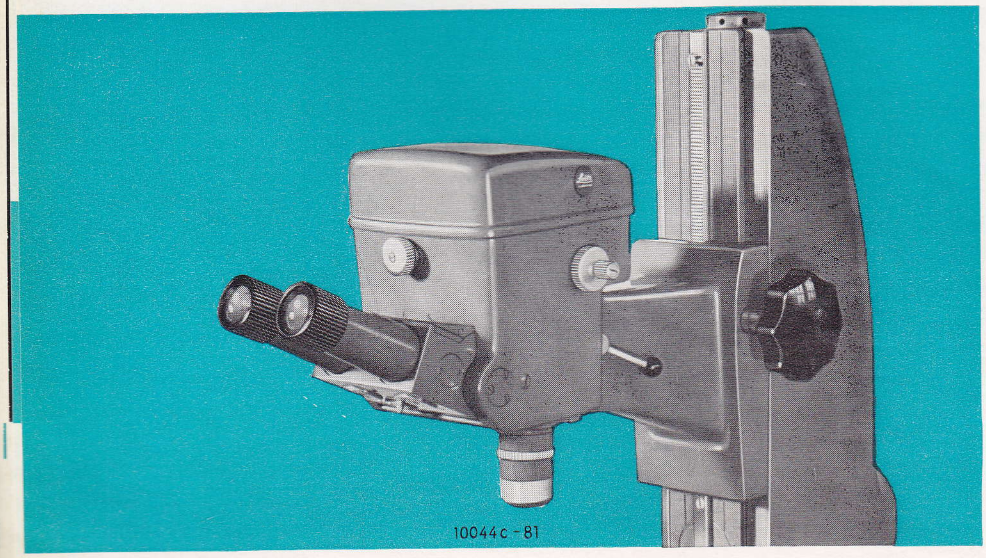
Detailed description: — List 81 — 16.

# Accessories for measuring microscopes

# Binocular measuring tube

### Technical data

| Objective intermediate image | Total magnification | Object field diameter | Aperture | Working distance |
|---|---|---|---|---|
| 1 : 1 | 10 x<br>20 x<br>30 x | 20 mm 0.79″<br>10 mm 0.39″<br>6.5 mm 0.26″ | 0.04 | 75 mm 3″ |
| 5 : 1 | 50 x<br>100 x<br>150 x | 4 mm 0.16″<br>2 mm 0.079″<br>1.3 mm 0.051″ | 0.14 | 37 mm 1.5″ |
| approx. 2 : 1 for double image attachment | 20 x | 10 mm 0.39″ | 0.066 | 85 mm 3.3″ |
| 2 : 1 for measuring knife edge device | 20 x<br>40 x<br>60 x | 10 mm 0.39″<br>5 mm 0.2″<br>3.3 mm 0.13″ | 0.066 | 85 mm 3.3″ |



### Description

The binocular measuring tube with upright and right-way-round image can be used on our WM and UWM toolmakers' microscopes and on the Leitz-Strasmann universal measuring machine. The observation tube of its viewing microscope can be inclined through 40° for horizontal observation; the eyepieces in correction mounts can be adjusted for the user's interpupillary distance.

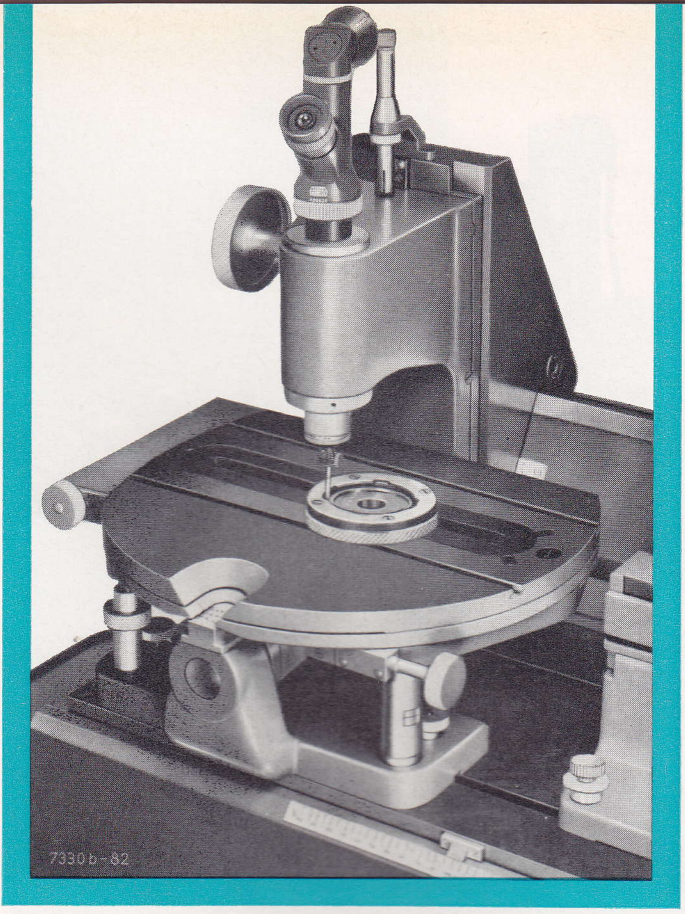
The telecentric objective which forms part of the basic outfit produces a 1 : 1 image of the testpiece in the plane of the graticule. The testpiece and graticule images appear together in the field of view of the viewing microscope, so that the same graticules can be used for the interchangeable magnifications from 10x to 150x. The graticules – with thread profiles, radii, or special drawings – are interchanged on a slide; individual profiles are introduced into the field of view by rotating a fine adjustment device.

For angle measurements the tube has a circle graduated from 0 to 360°, which can be read to 1 min. with the aid of an auxiliary scale. By actuating a lever the images of graduated circle and auxiliary scale appear in the field of view of the viewing microscope.

The objective for the 1 : 1 intermediate image can be exchanged for special objectives for other applications of the measuring tube. Thus, a 5 : 1 objective is available for higher magnifications up to 150 x, a 2 : 1 objective for use with measuring knife edges, and a double-image attachment for direct measurements of distances between bore holes and lines.

Detailed description: – List 81 – 13.

## Optical zero indicator



Optical zero indicator
on the universal comparator 200

### Technical data

| | | | |
|---|---|---|---|
| Measuring range | ± 20 | µm* | ± 0.001″ * |
| Scale unit | 2 | µm* | 0.0001″ * |
| Measuring force | approx. 7 | g | 0.25 oz. |

* for the tracers listed in the basic outfit.

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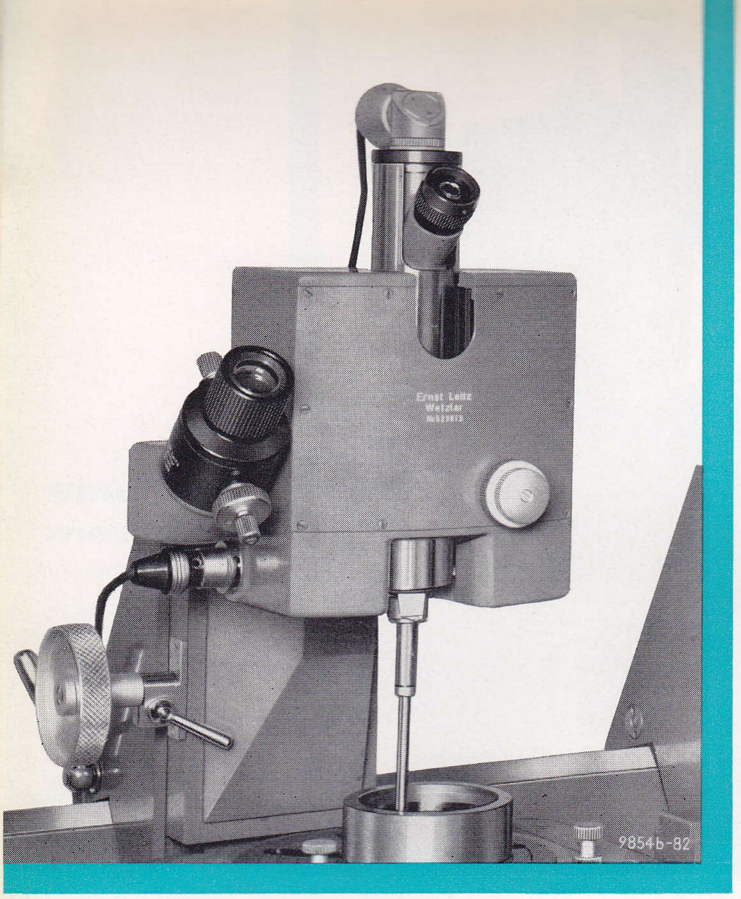
### Description

The optical zero indicator is used in our WM and UWM toolmakers' microscopes, the universal measuring machine, the universal comparator, and the optical master dividing head for graduation control and the measurement of optically inaccessible sites (e.g. undercuts).

In the optical zero indicator the image of illuminated cross lines is projected into the field of view of the eyepiece by means of a mirror system. If the test-piece touches the feeler whose measuring direction can be reversed, a mirror in the system is tilted and the projection ray path deflected. The zero position is determined with great accuracy if the projected image of the cross lines is centred between the double lines of the eyepiece by moving the workpiece. Divergences can be measured either with the basic accessories, or, within a range of ± 20 µm with the auxiliary graduation of the graticule.

Detailed description: — List 82—19.



# Internal measuring device

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### Technical data

| | | | |
|---|---|---|---|
| Measuring range of the vertical adjustment | 100 | mm | 4″ |
| Scale unit | 1 | µm | 0.00005″ |
| Measuring force | approx. 7 | g | 0.25 oz. |
| Smallest measurable internal thread | M 4 | | W 36 |

### Description

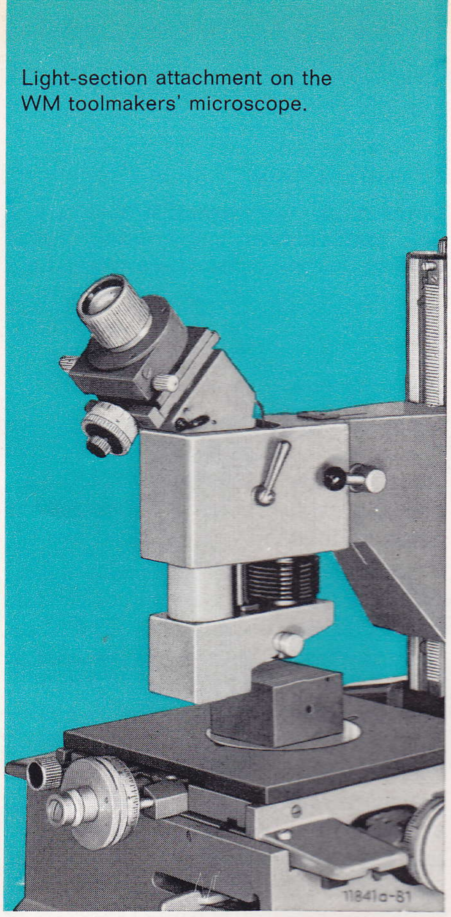
The internal measuring device can be attached to the UWM large toolmakers' microscope, the universal measuring machine and the universal comparator for the measurement of internal threads (effective diameters, pitch), bores, and internal and external cones.

The important elements of this instrument are a vertically adjustable spindle sleeve with a built-in precision scale, a scale reading device, and the optical zero indicator inserted in the spindle sleeve.

The weight of the spindle sleeve, which runs on ball bearings, is balanced by counterweights. The spindle sleeve can be adjusted vertically by a coarse- and fine adjustment; its position is read off the scale moving with the sleeve with the aid of an objective and a micrometer eyepiece.

The optical zero indicator built into the spindle sleeve corresponds in its design and function with the optical zero indicator described on p. 21. In the internal measuring device it has the sole function of determining culmination points.

Pitch measuring values are obtained on the built-in scale, but effective diameters can be determined with the facilities provided by the basic outfit. Several feelers with two same-size balls each are available for testing various pitches and effective thread diameters. The tracing lever is springloaded, so that forced horizontal movement of the feeler beyond the measuring range owing to accidental knocks will not cause any damage.


Light-section attachment on the WM toolmakers' microscope.

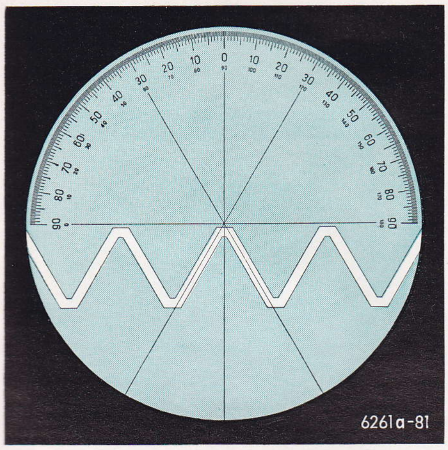
# Light-section attachment

**Technical data**

| | | | |
|---|---|---|---|
| **Magnification** | 30 | x | |
| **Object field diameter** | 6.5 | mm | 0.26″ |
| **Free working distance** | approx. 2 | mm | 0.08″ |
| **Angle measuring range** | ± 90 | ° | |
| **Scale unit** | 20 | min. | |
| **Linear measuring range** | 2 | mm | 0.08″ |
| **Scale unit** | 10 | µm | 0.0004″ |

**Description**

The light-section attachment is used for the measurement of profiles with the aid of a light section. The outstanding characteristic of this optical device is its undistorted image formation which is achieved because the emergent pencil of light cuts the profile under examination at an angle of 90°. The instrument reproduces, for instance, contours of surface textures, tool cutters, files, profile rollers, engravings, thread-rolling dies so that their measurement produces direct results without the need for conversions. A micrometer eyepiece permits linear and angle measurements. It can be replaced by other eyepieces with or without profile graticules. Mounted on a stand the light section attachment can be used as an independent instrument. Since it can also be combined with our measuring microscopes the measurements for which it is designed can be carried out over a large range with narrow tolerances.



Eyepiece field of view with light-section image of a thread-rolling die.

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# Double-image tube

## Technical data

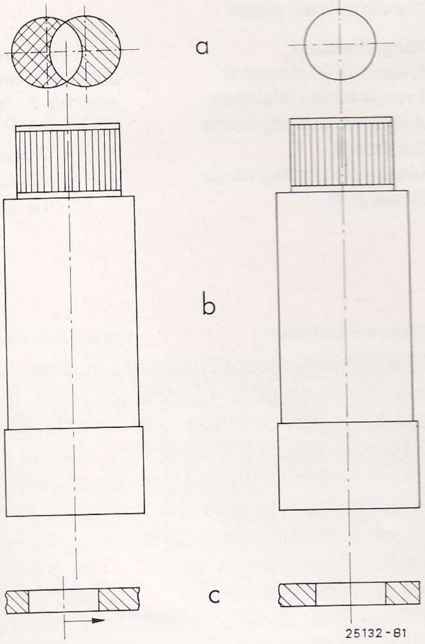
| | | | |
|---|---|---|---|
| Magnification | approx. 30 | x | |
| Object field diameter | 6 | mm | 0.24″ |
| Working distance | approx. 71 | mm | 2.8″ |

## Description

The double-image tube is used with our measuring microscopes mainly for measuring the distances between holes, and the measurement of scales and other graduations.

A prism system built into the lower part of the tube forms two side-reversed images of the object to be measured, such as a hole. The two images move in opposite directions when the object to be measured is moved; due to built-in filters they appear in complementary colours. The centre of the hole coincides precisely with the optical axis when it appears white, without colour fringes, in the eyepiece, i. e. when both images coincide.

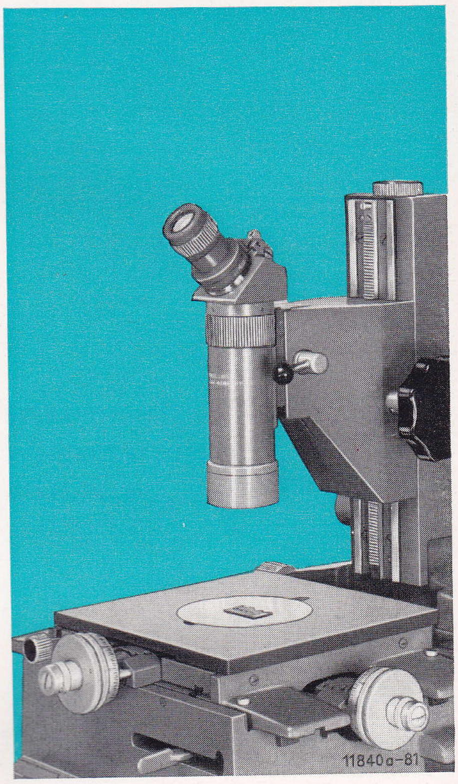
Distances between holes are measured directly by moving the measuring stage, without the need for determining the diameters of the bores.



a) eyepiece view
b) double image tube
c) object of measurement

Left: – The centre of the bore does not coincide with the optical axis. Two coloured part-images appear in the eyepiece.

Right: – The object of measurement has been displaced so that centre of the bore and optical axis coincide. A bright image appears in the eyepiece.



Double-image tube
on the WM toolmakers' microscope

# Goniometer eyepiece

### Technical data

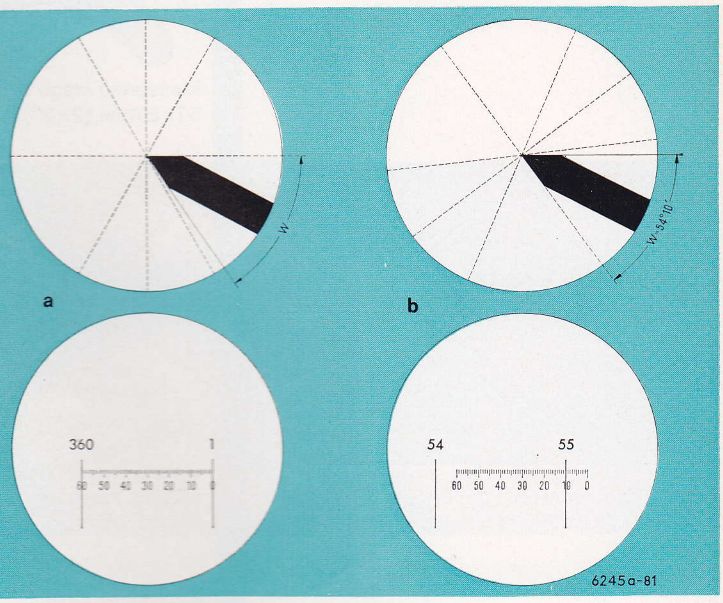
| | |
|---|---|
| Measuring range | 360 ° |
| Scale unit | 1 min. |

### Description

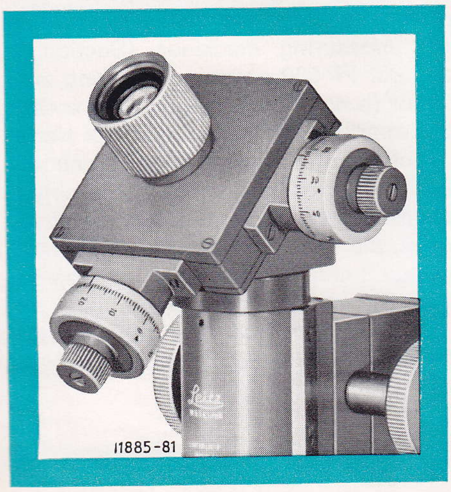
The goniometer eyepiece can replace the standard eyepiece in the measuring tubes of our measuring microscopes for the measurement of angles. The eyepiece contains a rotating graticule with fixed 90° and 60° angles and a glass circle graduated in °, which can be read to 1 min. with the microscope and the eyepiece graduation.

**Goniometer eyepiece with microscope tube of the WM toolmakers' microscope**

Determination of the flank angle of a cutting tool with the goniometer eyepiece
**a**
1st setting 1°
**b**
2nd setting
55° 10′
Measuring value
54° 10′



# Screw micrometer eyepiece



### Technical data

| | | |
|---|---|---|
| Eyepiece magnification | approx. 10 x | |
| Measuring range in the intermediate image plane | 6 mm * | 0.25″ * |
| Measuring range in the intermediate image plane with y-times objective magnification | $\frac{6}{y}$ mm | $\frac{0.25''}{y}$ |
| Scale unit for the intermediate image plane | 5 $\mu$m | 0.000125″ |
| Scale unit with y-times objective magnification | $\frac{5}{y}$ $\mu$m | $\frac{0.000125''}{y}$ |

* for one or two coordinates as desired

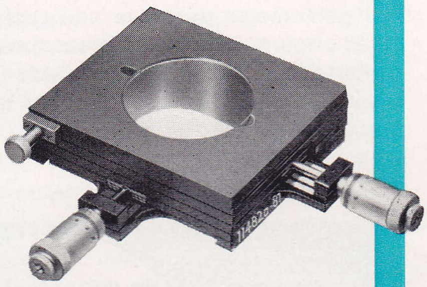
### Description

The screw micrometer eyepiece – with bayonet fitting – can be replaced by the standard eyepieces of our measuring microscopes for linear measurements.

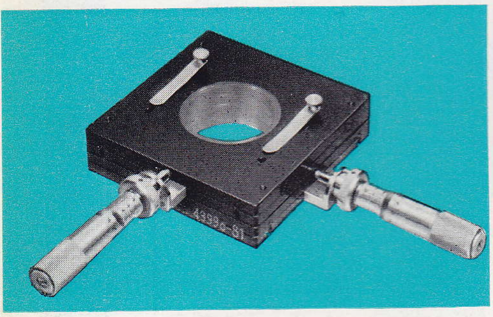
The measuring value is determined with the aid of a graticule located in the intermediate image plane and the drum scales of the measuring spindles.

Detailed description: – List No. 51–17.

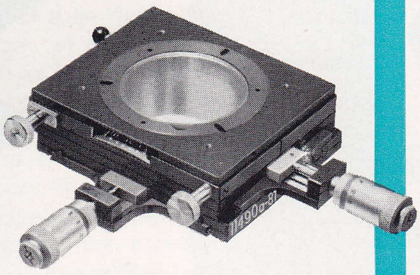
# Measuring stage 25 or 50 mm (1" or 2")



Measuring stage with
50 x 50 mm (2 x 2") measuring range



Measuring stage with
25 x 25 mm (1 x 1") measuring range



Measuring stage with built-in
rotating stage,
50 x 50 mm (2 x 2") measuring range

### Description

The Leitz measuring stages are available in various models to suit different purposes: – with or without T-slots, for screwing down or with magnetic feet, fitted for one or two measuring directions. All stages move on tracks with steel ball bearings, so that even after prolonged use no tilting or measuring errors will occur due to mechanical wear. In addition, this design support higher loads than slide ways. Center cradles, gear testers, mounts for small parts, etc. are available for all measuring stages.

The movement in one or two coordinates is adjusted with micrometer spindles only in stages of up to 25 mm (1") measuring range, and with spindles and slip gauges in stages of up to 50 mm (2") measuring range.

Measuring stages of 25 mm (1") measuring range are used with some of our measuring microscopes (Section 1), the TP 200 bench projector (p. 45), the reflected light interference microscope (p. 50), and the Miniload hardness tester (p. 57). They are provided with a central aperture and glass insert for transmitted and incident light, and with a solid surface for incident-light observations only.

Measuring stages for the 50 mm (2") measuring range are used with some of our measuring machines (Section 1) and our PP 500 contour measuring projector (p. 46). These stages have a central aperture and glass insert for transmitted- and incident-light observations. For the perfect alignment of the object to be measured to the direction of movement, the upper stage plate is mounted so that it can be rotated through approx. 15°. This stage is supplied as a special model with a built-in rotating stage (rotating through 360°, vernier readings to 2 min.).

### Technical data

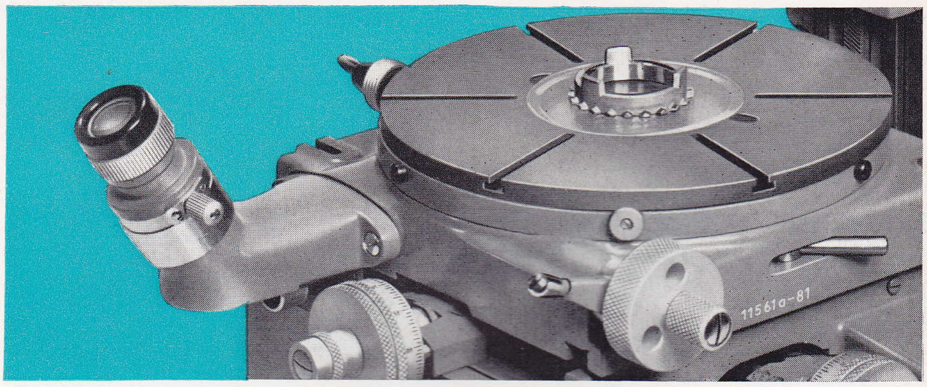
| Measuring stage 25 mm (1") | | | |
|---|---|---|---|
| Measuring range | 25 x 25 | mm | 1 x 1" |
| Scale unit | 10 | µm | 0.0005" |
| Clamping area | 120 x 120 | mm | 4.7 x 4.7" |
| Diameter of the glass insert | 59 | mm | 2.3" |
| Weight | approx. 3 | kg | 6.6 lbs. |

| Measuring stage 50 mm (2") | | | |
|---|---|---|---|
| Measuring range | 50 x 50 | mm | 2 x 2" |
| Scale unit | 10 | µm | 0.0005" |
| Clamping area | 180 x 155 | mm | 7 x 6" |
| Diameter of the glass insert | 100 | mm | 4" |
| Weight | approx. 7 | kg | 15 lbs. |

**Technical data**

| | | | |
|---|---|---|---|
| Diameter of the mounting surface | 214 | mm | 8.4″ |
| Diameter of the glass insert | 92 | mm | 3.6″ |
| Rotating range | 360 | ° | |
| Scale unit | 1 | min. | |
| Weight | approx. 15 | kg | 33 lbs. |

## Optical rotating stage



**Description**

The optical rotating stage is used for measurements of angles in the toolmakers' microscope, the universal measuring machine, and the projection measuring stage for the UWM; however, it can also be used independently, e. g. on machine tools.

The division of the built-in graduated circle is projected on to the intermediate image plane of a reading microscope. A graticule which can be moved for the setting of integral values, and is located in the intermediate image plane subdivides 1° of the graduated circle into 60 divisions. Graduated circle and graticule are read by an eyepiece attachment.

Permanently centred crosslines are mounted in the axis of rotation of the lower stage. For the centring of workpieces the upper stage with its grooves can be adjusted relative to the lower stage with the aid of two knurled screws.

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# Measuring stage 150 x 60mm (6″x2.36″)

**with built-in rotating stage**

### Description

The measuring stage 150 mm x 60 mm (6x2.36″) with built-in rotating stage is used with the UWM large toolmakers' microscope (p. 12) and the GP 650 large contour measuring projector (p. 47). It can be longitudinally and transversely adjusted by means of micrometer spindles and slip gauges. The stage, moving on rollers is fully supported over the entire measuring range in both directions. The horizontal tracks carry the table, while lateral guidance is provided by rollers and spring-mounted ball bearings on surfaces at right angles to the tracks. The stage is pulled against the micrometer spindles and slip gauges in both directions by means of weights or spring traction. Centrifugal governors control the movement. An orientating scale on the front of the stage indicates the stage position.

The drum index of the micrometer spindles can be rotated, and can be set, e. g. at the beginning of a measurement, at an approximate value. The measuring surfaces of the spindles do not rotate; this guarantees satisfactory fit and negligible wear of the slip gauges.

The rotating stage built into the measuring stage can be moved by means of a rack-and-pinion drive and arrested by means of a torsion-free clamping mechanism.

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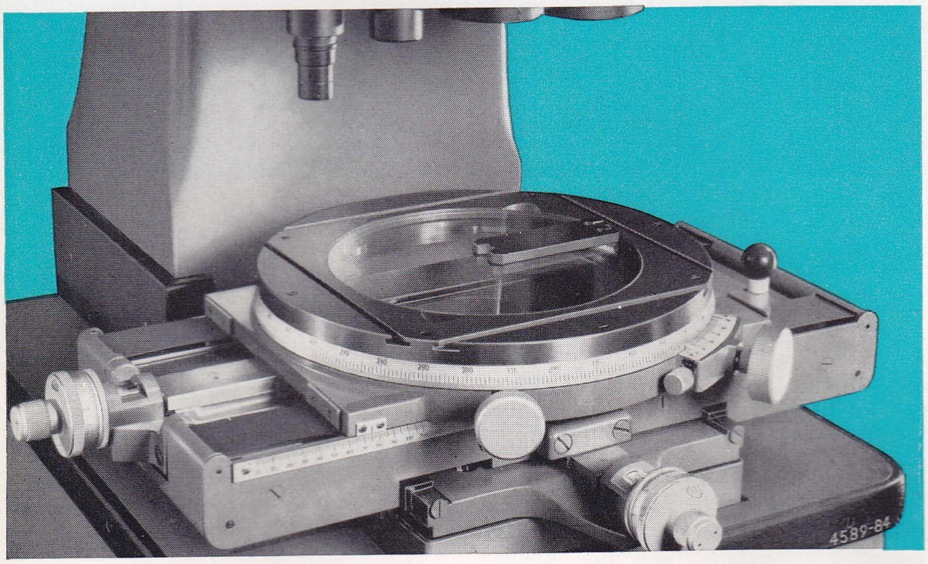


### Technical data

| | | | |
|---|---|---|---|
| Range of the | | | |
| longitudinal adjustment | 150 | mm | 6″ |
| transverse adjustment | 60 | mm | 2.36″ |
| Scale unit of the measuring spindles | 5 | µm | 0.0001″ |
| Rotating range | 360 | ° | |
| Vernier reading | 2 | mins. | |
| Diameter of the mounting surface | 310 | mm | 12.2″ |
| Diameter of the glass insert | 215 | mm | 8.5″ |
| Weight | approx. 46 | kg | 100 lbs. |

# 2. Optical linear measurement with mechanical tracing

The linear measuring instruments with mechanical tracing can be divided into two groups: –

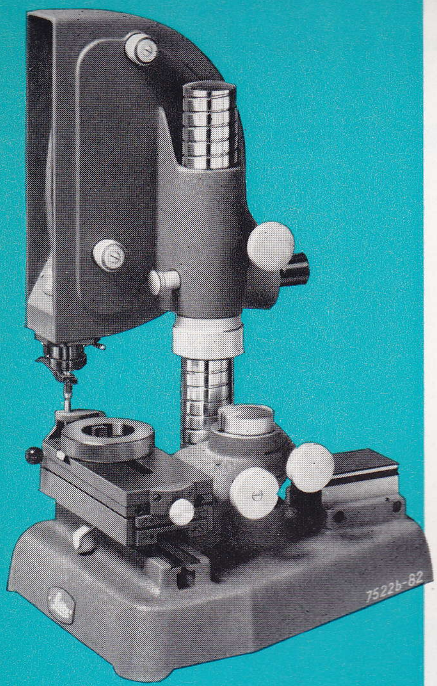
Instruments for difference measurements

Instruments for direct measurements.

Difference measuring instruments (Tolerator etc.) are set at the specified size by means of a master (slip gauge, sample). They indicate the deviation from the set value, and are mainly used for serial measurements.

Instruments for direct measurements (vertical linear precision gauge) indicate the measurement of the testpiece directly. They are therefore particularly suitable for individual measurements.

The stages and contact tips of these measuring instruments are interchangeable, and can be chosen to suit the measuring problem or the physical shape of the object to be measured. Stage or contact plunger can be adjusted with the aid of a quartz mirror gauge block (p. 34) so that the stage and the plane measuring surface of a contact tip can be aligned parallel to each other. The normal measuring force is 200 g, however, for special purposes instruments with greater or smaller measuring forces are available.



Tolerator for external and internal measurements

# LEITZ TOLERATOR® comparator gauge

### Examples of uses

Serial measurements, general difference measurements.

### Description

The Tolerator is a reliable and robust difference measuring instrument which can also be used for direct linear measurements of up to 0.14 mm.

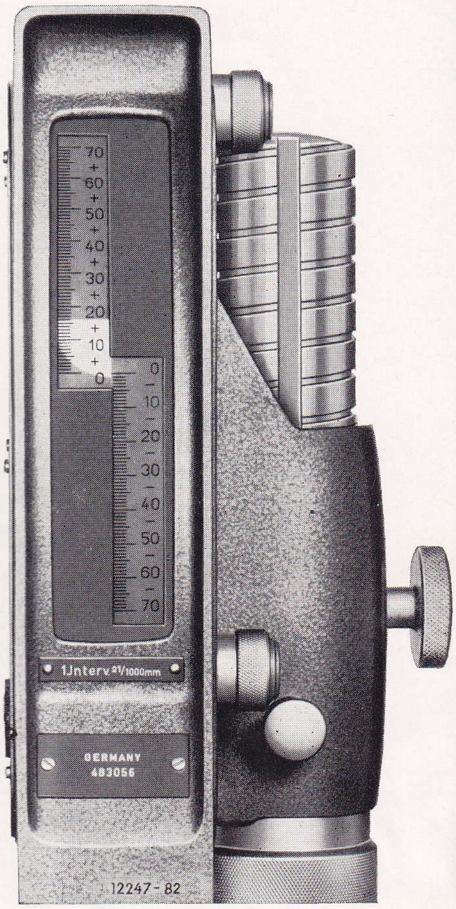
The zero position for a specified size is set with a setting gauge (slip gauge, adjusting gauge, sample), and the measured deviation read on the projection scale.

A tilting mirror connected with the measuring plunger produces an image of a light spot on the projected scale, on which negative and positive deviations from the norm can be read separately. The limits of the tolerance zones are indicated by adjustable coloured tolerance bands, so that the zones "passed", "scrap" and "reject" are recognized at a glance.

Contact tips and anvils are interchangeable for adaptation to the physical shape of the testpiece.

On a special stand the tolerator can be used for external and internal measurements.

Detailed description: — List No. 82—8.



Scale image:
Light spot at ± 16 µm

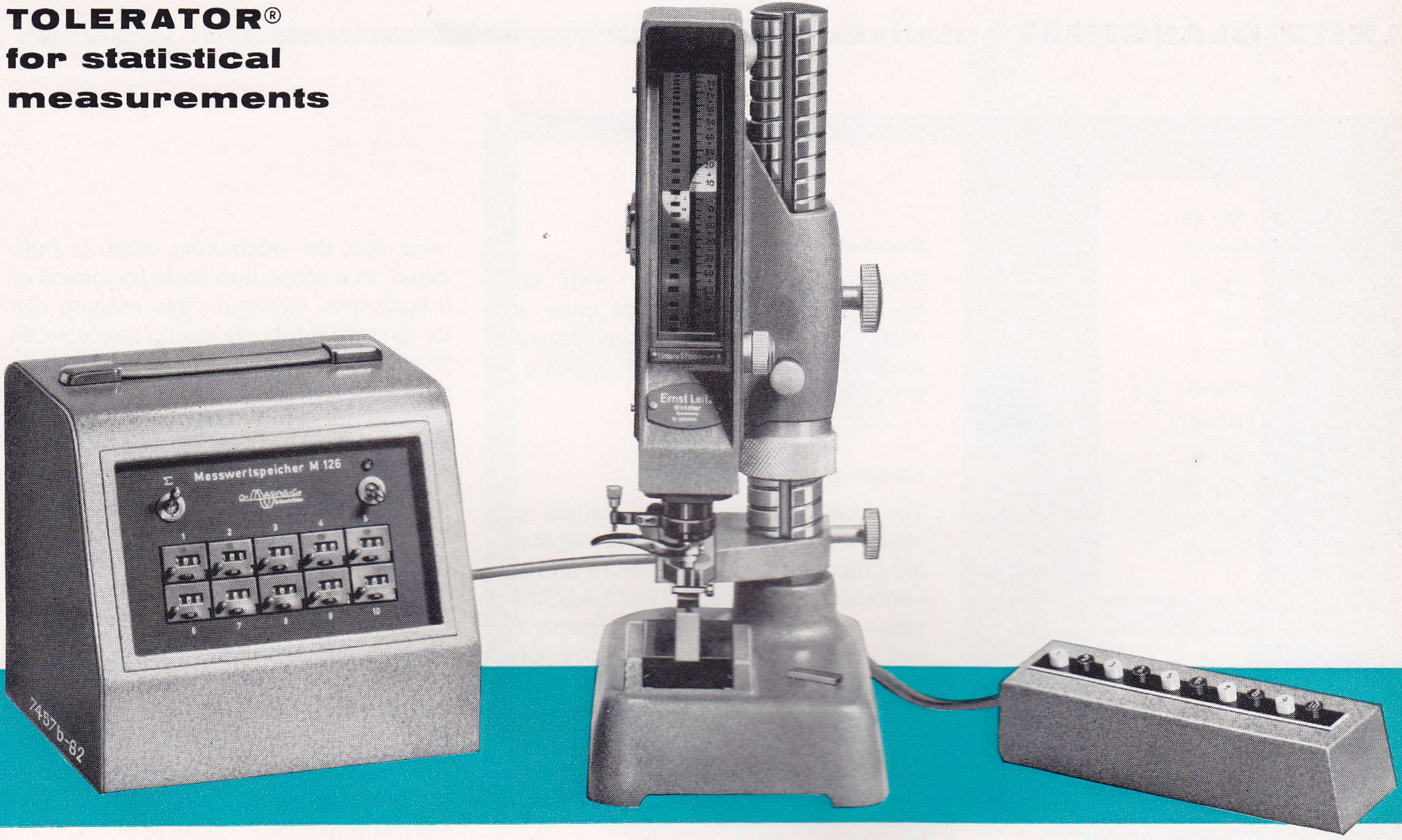
### Technical data

| | | | | | |
|---|---|---|---|---|---|
| **Measuring range** | **± 35 µm** | **± 0.001375″** | **or** | **± 70 µm** | **± 0.0025″** |
| **Scale unit** | **0.5 µm** | **0.000025″** | | **1 µm** | **0.00005″** |
| **Scale interval** | **1.2 mm** | **0.05″** | | | |
| **Maximum height of test piece** | **100 mm** | **4″** | | | |
| **Measuring pressure** | **approx. 200 g** | **7 oz.** | | | |
| **Height x width x depth** | **420 x 160 x 200 mm** | **16.5 x 6.3 x 8″** | | | |
| **Weight** | **approx. 16 kg** | **35 lbs.** | | | |

## TOLERATOR®
## for statistical measurements

### Technical data

| | | | |
|---|---|---|---|
| Measuring range | ± 70 | μm | |
| Scale unit | 1 | μm | |
| Scale interval | 1.2 | mm | |
| Number of classes | 1–12 and 1–16 | | |
| Class width, adjustable | 2–10 | μm | |
| Height x width x depth | 420 x 160 x 200 | mm | 16.5 x 6.3 x 8″ |
| Weight | approx. 25 | kg | 55 lbs. |



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### Examples of uses

Statistical measurements during serial inspections; for the evaluation of spot checks in connection with counters and storage units as illustrated here.

### Description

The special model of the tolerator for statistical measurements allows the direct determination of the percentage of ″scrap″, ″passes″, and ″rejects″ of the total production by substituting a small spot check of the current series, for the time-consuming total count. The advantages of statistical quality control can be utilized for acceptance and quality inspection.

This model differs from the standard tolerator in the absence of tolerance bands. The positive and negative graduation of the measuring scale is arranged on one side of the groundglass screen, while the adjustable class graduation appears on the other side as an adjustable band with class widths (2, 3, 4, 6, 8, 10 μm) increasing in groups. The class graduation consists of alternating bright and dark fields numbered consecutively 1 – 12 and 1 – 16 respectively.

The measurements are evaluated with rosters or with statistical counters.

Detailed description: – List 82 – 8.

### Technical data

| | | | |
|---|---|---|---|
| Measuring range | ± 60 | μm | |
| Scale unit | 1 | μm | |
| Number of classes | 10 | | |
| Class widths (adjustable) | 2 . . . 10 | μm | |
| Maximum testpiece height | 100 | mm | 4″ |
| Height x width x depth | 550 x 220 x 350 | mm | 22 x 8.7 x 14″ |
| Weight (including evaluating instruments) | approx. 50 | kg | 110 lbs. |

# LEITZ-CLASSIMAT® statistical measuring instrument

### Examples of uses

Statistical measurements with automatically controlled storage units; machine control based on the measurement of random samples, sorting of workpieces into classes.

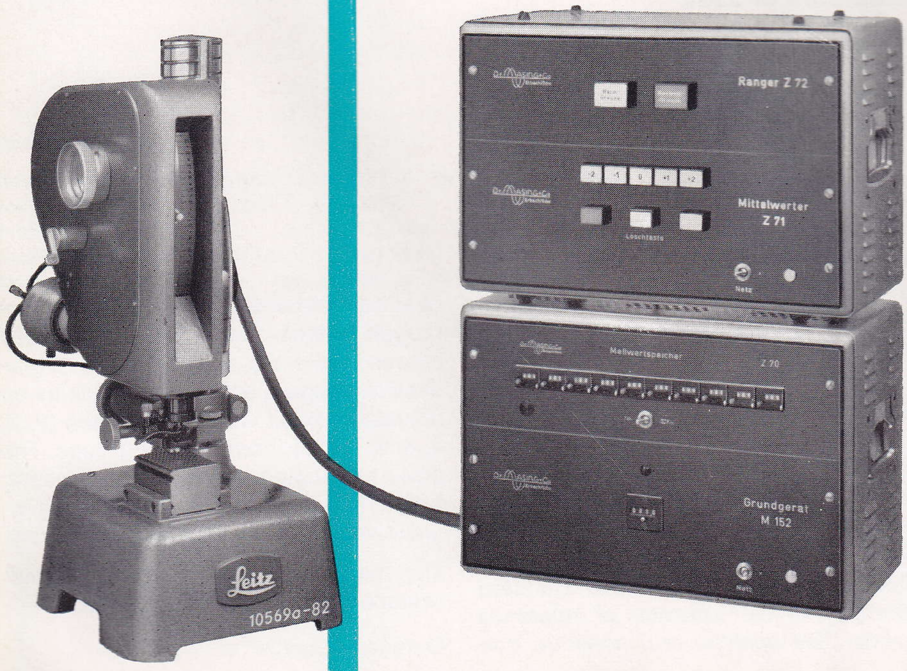
### Description

The statistical measuring method provides the production control necessary for rational serial manufacture and prevents scrap and rejects. The CLASSIMAT statistical measuring instrument has been developed for this purpose; practical requirements for simplicity of operation have played a decisive role in its design.

The CLASSIMAT operates according to the system of the TOLERATOR (p. 30); here, too, the measuring value is indicated on a projection scale by means of a light spot. However, this reading can be ignored if the evaluating instruments have been connected, because the light spot also affects a photo-electric transmitter with which the tolerance zone can be divided into 10 classes with adjustable widths. According to the position of the light spot the photo-electric transmitter sends a pulse to the evaluating instruments. The classification error of individual measuring values does not exceed $^1/_{10}$ of the class size.

Various evaluating instruments can be connected with the CLASSIMAT, extending the range of this instrument from statistical quality control to the automatic control of machine tools.

Detailed description: – List 82–10.

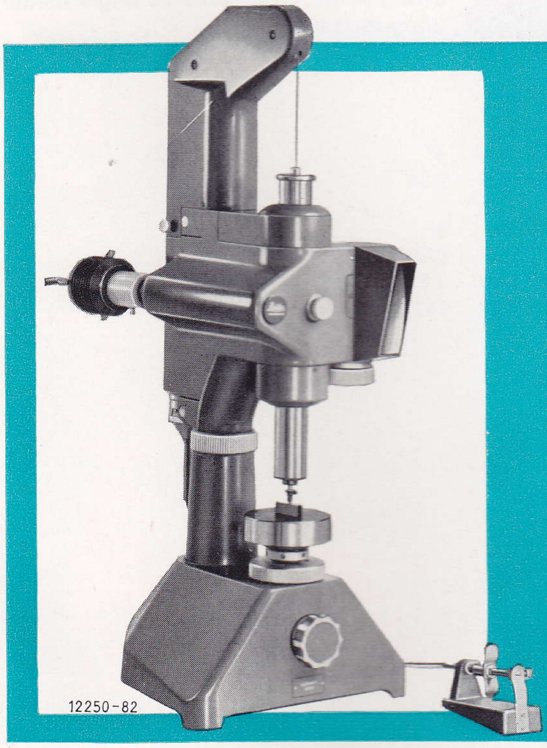


CLASSIMAT
with evaluating
instruments

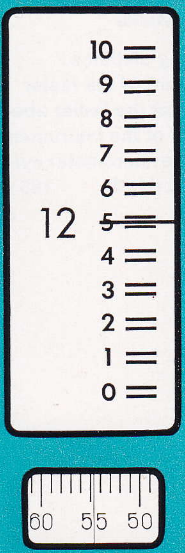
**Technical data**

| | | | |
|---|---|---|---|
| Measuring ranges | 0 . . . 100 | mm | 0 . . . 4″ |
| | 100 . . . 200 | mm | 4 . . . 8″ |
| Scale unit | 1 | $\mu$m | 0.000025″ |
| Scale interval | 1.7 | mm | 0.034″ |
| Height x width x depth | 820 x 300 x 330 | mm | 32 x 12 x 13″ |
| Weight | approx. 55 | kg | 120 lbs. |

# Vertical linear precision gauge



12250-82



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Scale of the vertical linear precision gauge; measured value: $12.554^8$ mm

### Examples of uses

Direct linear measurements, particularly for production of prototypes or individual parts in workshop and inspection department.

Determination of effective thread diameters by the three-wire method.

### Description

The vertical linear precision gauge is fitted with a vertically adjustable measuring plunger with built-in precision scale illuminated by a low-voltage lamp. The image of the scale division is projected on to a groundglass screen and symmetrically set between the double lines of the groundglass scale. The contact tip is lifted by means of a Bowden cable eliminating the effect of hand heat on the measuring result. Slip gauges and similar standards are not required for setting the instrument*. Various dimensions of a testpiece can be measured successively without the need for resetting the instrument.

Abbe's Principle has been strictly adhered to in the design of this instrument; measuring distance and scale are arranged end-to-end in the measuring direction. The measuring value is read directly to 1 $\mu$m, the 4th decimal (0.1 $\mu$m) can be estimated. The bright, magnified projection image ensures strain-free operation even in broad daylight.

Contact tips and anvils are interchangeable and can be chosen to suit the task. A thread measuring device is available for thread measurements according to the three-wire method.

Detailed description: — List 82—20.

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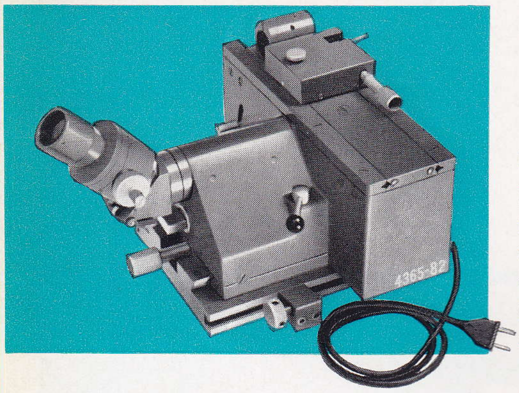
* For the adjustment of the measuring head from the 0-100 mm (0-4″) to the 100-200 mm (4-8″) measuring range only a 100 mm (4″) slip gauge is used.

## Optical linear measuring slide



### Technical data

| | | | |
|---|---|---|---|
| Axial measuring distance | 100 | mm | 4″ |
| Radial movement of the feeler | 60 | mm | 2.36″ |
| Normal height of the feeler above the lower edge of the instrument | 150 | mm | 6″ |
| Scale unit of the micrometer eyepiece | 1 | μm | 0.00005″ |
| Height x width x depth | 185 x 300 x 320 | mm | 7.3 x 12 x 12.6″ |
| Weight | approx. 20 | kg | 44 lbs. |

### Examples of uses

For testing and measuring the pitch and tumbling error of thread spindles, worms, hobs, and cams in connection with our optical master dividing head (p. 36) or any other suitable angle measuring instrument.

### Description

The optical linear measuring slide consists of the baseplate, the main body, and the slide with tracing device. It is mounted with its baseplate on raiser blocks or levelling plates, or on the baseplate of our Optical Master Dividing head.

Built into the main body is a measuring microscope with a micrometer eyepiece for reading the scale mounted on the slide. The slide with the tracing device can be moved in both directions by means of reversible spring tension, so that the instrument can measure surfaces from the left or from the right, e.g. the right- and left-hand flanks of a thread.

The slide moves on enclosed rollers. It carries the scale, protected against dirt, the tracing device, and special provision for the attachment of a conventional indicator for purposes of alignment.

Detailed description: — List 82—1.

## Quartz mirror gauge block

### Technical data

| | | |
|---|---|---|
| Height | 10 | mm |
| Degree of accuracy | "0" | |

### Examples of uses

For the parallel alignment of plane measuring surfaces with vertically mounted indicators.

### Description

In order to avoid faulty measurement due to contact errors during mechanical tracing, the surface of the measuring stage and the plane measuring surface of the contact tip must be parallel in a linear measuring instrument. The quartz mirror gauge block is used for alignment; interference bands are produced by convergence of lines by means of a silvered surface. One measuring surface can be rendered parallel with the other by means of adjustments on the instrument, when the interference bands will disappear. Due to its accuracy the quartz mirror gauge block can also be used for setting the rated value in combination with slip gauges. Detailed description: — List 86—11.

# 3.

# Angle measurement

In industrial metrology, technical angle measurement occupies a place similar to that of linear measuring techniques, since many objects to be measured call for the mastery of both types of measurement.

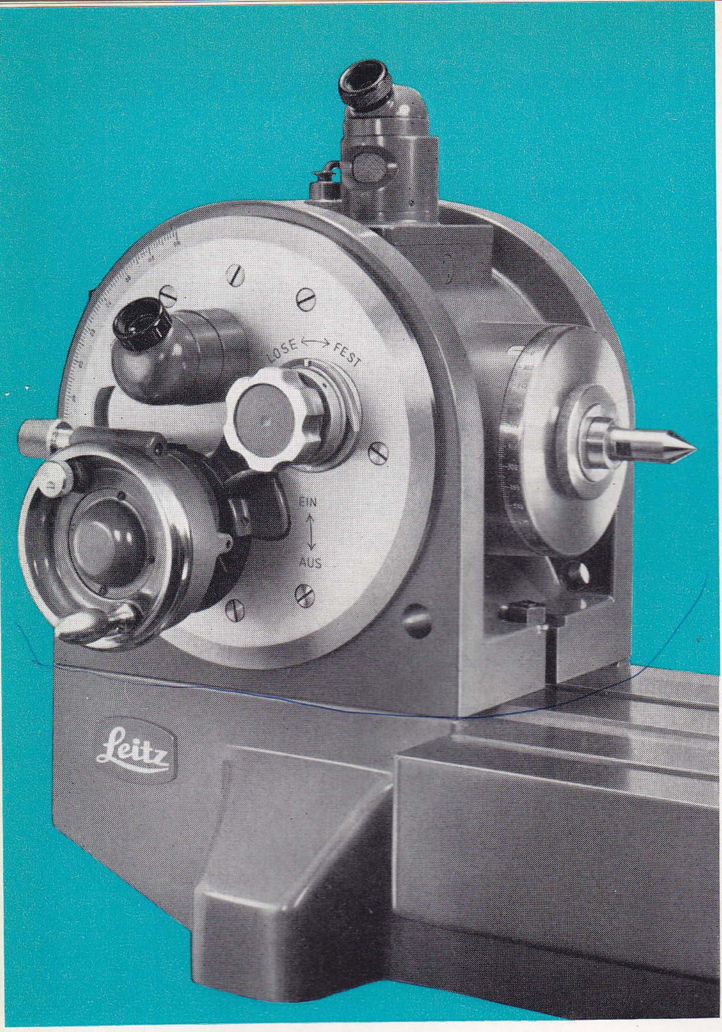
Units of angle measurement (defined by DIN 1315) are the arc and the degree. Since the numerical value of the arc measurement — on the standard circle for the full angle $2\pi = 6.28318\ldots.$ — cannot be divided integrally it has only mathematical significance for the metrologist. In technical angle measurements degrees with subdivisions of minutes and seconds of arc are generally used. This sexagesimal subdivision often calls for cumbersome conversions, so that measurements and calculations only within one range of units, degrees, minutes, or seconds, should be aimed at. Although the angle unit as a distance ratio is reproducible at any time and does therefore not need any conversion in to other measuring systems, a number of angle standards such as graduated circles, mirror polygons, angle gauges etc. are indispensable for practical work in the workshop or the inspection department.

If the measurement of an angle is based on comparison with a graduated circle as the measuring element two conditions must be fulfilled: coincidence of apex, and coincidence of sides. Since all graduated circles suffer from residual errors of eccentricity to the axis of rotation, the condition of apical coincidence can be met only within limits, if at all. Hence, special principles of compensation must be applied in the design of angle measuring instruments in order to increase their accuracy. It is therefore possible to eliminate the effects of eccentricity errors of the graduated circle by means of the double pick-up principle: – two diametrically opposed divisions (e. g. 0° and 180°) are combined in a single image plane, when the errors will cancel each other as they are opposite and equal. Where measuring tolerances are less critical unilateral optical readings with appropriate subdivisions, or the index line, or vernier readings are used.

Errors of apical coincidence in testpiece measurements, decrease in their effect as the sides of the angle increase in length. The case of infinite side length which no longer requires apical coincidence can be realized with measuring telescopes having a parallel beam path. These are specially designed for angle measurements as autocollimators (p. 40). Mirror polygons which need not be centred serve as angle standards in combination with such collimators.

In addition to the already mentioned graduated circles and polygons, angle gauges and, in connection with linear slip gauges and collimators, sine rules are also available for angle measurement.

Modern developments in the field of goniometry are photo-electric instruments which convert light pulses into electrical pulses. The photo-electric incremental angle transducer described in some detail on p. 66 is a characteristic example of this type of instrument.



# Optical master dividing head

≈ $6500

chuck - $200.00

### Technical data

| | | | |
|---|---|---|---|
| Graduated circle of the spindle divided into | 360 | ° | |
| Angle division of the graduated circle | 20 | min. | |
| Scale unit of the precision reading | | | |
| (coincidence reading) | 2 | sec. | |
| (symmetrical setting) | 1 | sec. | |
| Tilting range of the spindle housing | 0...100 | ° | |
| Tilting scale unit | 1 | min. | |
| Taper socket | Morse 4 | | |
| Normal center height | 150 | mm | 6″ |
| Height x width x depth | 380 x 385 x 330 | mm | 15 x 15.2 x 13″ |
| Weight | approx. 80 | kg | 176 lbs. |

### Examples of uses

Instrument for angle measurements and for work on gearwheels, graduated plates, camshafts, circular scales, cam plates, etc., control of gyroscopic devices.

### Description

The graduated circle of the dividing head, which is rigidly connected with the spindle, is read by means of a microscope. In order to render eccentricity errors of the graduated circle ineffective the reading is based on the double pick-up principle. By means of two objectives two diametrically opposed lines on the circular scale (e.g. 0° and 180°) are compared in one image plane.

The spindle moves in spherical anti-friction bearings specially developed for the dividing head. It runs extremely smoothly and without play in any direction of rotation. It is arrested free from distorsion by means of a differential double clamp.

The drive of the spindle with wormwheel and worm does not affect dividing or measuring accuracy. The manual wormwheel drive is mounted in the anterior side wall of the dividing head, and can be swung out. Independently engaged and disengaged a fine adjustment provides additional gear reduction.

The spindle housing can be tilted through 100° and clamped in any position by means of two band brakes. The circular scale on the outside of the housing serves for the coarse tilt adjustment; fine adjustment is carried out optically by means of a built-in segment scale of a graduated circle.

An attachable motor permits work on the trued-up arbor, center, or on workpieces, which eliminates errors of eccentricity.

The cam tester (p. 37) and the optical linear measuring slide (p. 34) are the most noteworthy accessories for the optical master dividing head. The cam tester is particularly suitable for the measurement of angular displacements and the shape of cams.

The optical linear measuring slide is used for the measurement and testing of pitches of threaded spindles, worms, cams, etc.

Beds of various dimensions are available for work with the optical dividing head; they are mounted together with the dividing head on a welded steel cabinet which contains the connections for motor and illumination.

Detailed description: – List 82–1.

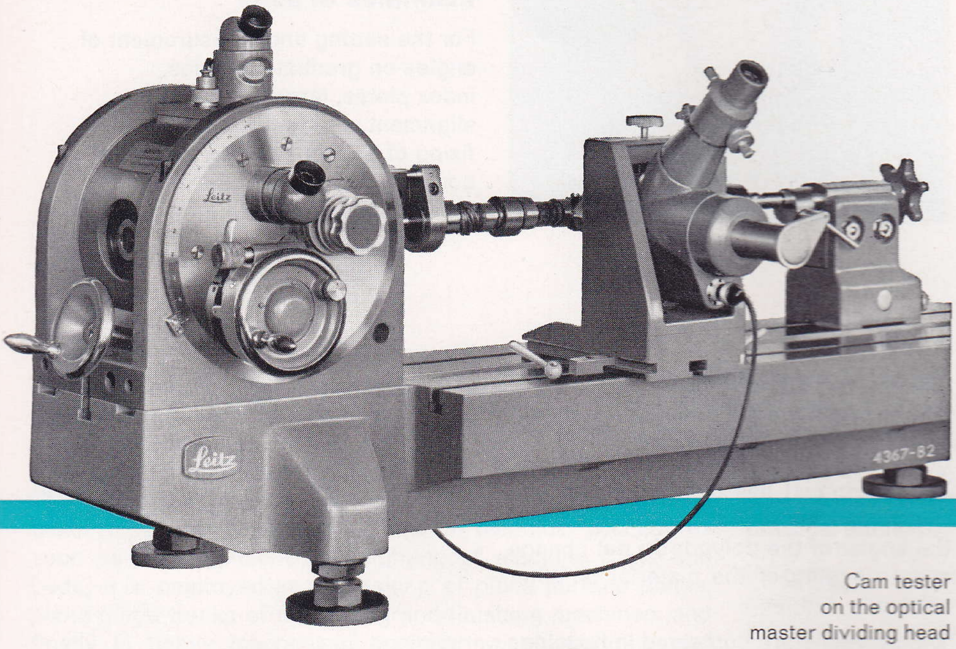
# Cam tester

### Technical data

| | | | |
|---|---|---|---|
| Normal height of spindle sleeve | 150 | mm | 6″ |
| Vertical adjustment | ± 10 | mm | ± 0.4″ |
| Measuring range of the spindle sleeve | 100 | mm | 4″ |
| Scale unit of the micrometer eyepiece | 1 | μm | 0.00005″ |
| Weight | approx. 15 | kg | 33 lbs. |

### Examples of uses

For the testing and measurement of angular displacement of cams, shape of cams, and radial pitch in cam plates.



Cam tester
on the optical
master dividing head

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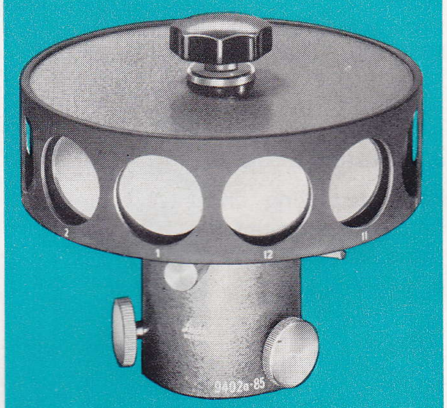
### Description

In connection with our optical master dividing head (p. 36) the cam tester determines, e. g., angular displacements of cams with accuracy. It locates the points of culmination of the cams, the appropriate angle values are read on the dividing head. The instrument is placed on the bed of the dividing head and fixed by means of a clamping device. It can be displaced parallel to the axis of the workpiece without the need for re-alignment. The cam tester consists chiefly of a horizontal linear measuring spindle sleeve, accurately guided in a housing, with a glass scale; it is moved against the test piece with a measuring force of approximately 200 g. The glass scale and the remainder of the optics are protected against dust. The scale is illuminated by an easily interchangeable lamp (8 v 5 W) and read by means of a micrometer eyepiece. The mandrel at the end of the spindle sleeve for contacting the testpiece accepts contact tips of various shapes. The spindle sleeve can be clamped by means of an arresting device, e. g. when the testpiece is changed or during the transport of the instrument. The vertical adjustment of the spindle sleeve is made possible by a vertical dovetail slide. When the clamp is released the spindle sleeve can be adjusted with an easily accessible knurled screw.

Detailed description: — List 82 — 1.

## Mirror polygons



Mirror polygon
in housing

### Examples of uses

For the setting and measurement of angles on graduated circles, index plates, large gearwheels; alignment work on spindles; fixing of angles between structural components etc. with the aid of the auto-collimator (p. 40).

### Description

The LEITZ mirror polygon consists of a compact glass body with a regular polygon for a base. The lateral surfaces are ground, optically polished, and silvered. The instrument has been designed and the glass chosen and finished so that the angles of the polygon do not change due to ageing of the material or other effects.

The polygons are contained in housings which permit the parallel alignment of the polygon axis with the axis of rotation of the object of measurement by means of four knurled screws. The shaft of the housing has a hole to receive a second shaft.

LEITZ mirror polygons are checked in our measuring departments and supplied with acceptance reports. The correction values contained therein show such small errors that in combination with our auto-collimator (p. 40) the polygons represent angle standards for measurements of the highest precision.

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### Technical data

| | | | | | |
|---|---|---|---|---|---|
| Number of mirror surfaces (Standard models, other numbers of surfaces on request) | 4 | 8 | 10 | 12 | 36 |
| Diameter of housing opening mm (″) | 38 (1.5) | 38 (1.5) | 38 (1.5) | 38 (1.5) | 20.5 (0.8) |
| Area height x width mm (″) approx. | 42 x 42<br>(1.65 x 1.65) | 42 x 42<br>(1.65 x 1.65) | 42 x 42<br>(1.65 x 1.65) | 42 x 42<br>(1.65 x 1.65) | 34 x 20<br>(1.34 x 0.8) |
| Diameter of polygon body mm (″) | 66.5 (2.6) | 116 (4.6) | 144 (5.7) | 170.6 (6.7) | 237 (9.3) |
| Socket of housing | 40 mm diameter H 6 | | | | |
| Maximum deviation from the rated angle | ± 2 sec. | | | | |
| Error of fault indication according to the type of measurement | | | | | |
| a) comparison with standard polygon | $2\sigma = \pm 0.7$ sec. | | | | |
| b) independent measurement (additional cost) | $2\sigma = \pm 0.2$ to 0.4 sec. according to the number of surfaces | | | | |

# 4.

# Alignment and direction testing

Precision mechanical engineering, heavy mechanical engineering, and machine tool engineering make such stringent demands on the accuracy of alignment and direction testing, that optical measuring methods have become necessary. The telescope plays a considerable part in solving these tasks. It is even used in fundamental technical procedures such as the alignment and sighting of machine parts and beds; it is employed in the making of plane surface plates, plane guide tracks of measuring and finishing machines, and finally in heavy mechanical engineering, shipbuilding and aircraft engineering, e. g. for the sighting of bores and the alignment of girders and cross members.

While most precision measuring instruments represent integrated units on which the testpiece is placed for measurement, alignment and direction measurements require instruments which are operational units only when combined with collimators, index marks, prisms, mirrors, and mirror bases and which allow the measurement and correction of small deviations in machines, completed or under construction. Optical methods are particularly suitable for this purpose since the straight-line propagation of light permits a more reliable determination of deviations than comparison with a physical standard.

In order to assemble the accessories for any measuring task the user requires knowledge of only elementary optical principles. Our detailed operating instructions as well as consultations which we will be pleased to arrange at any time will assist him in his choice.

For workshop use it is recommended to tabulate the methods of frequently recurring measurements in the form of measuring and evaluation sheets. Experience has shown that procedures prepared in this way can be carried out quickly and reliably even by staff of average training.

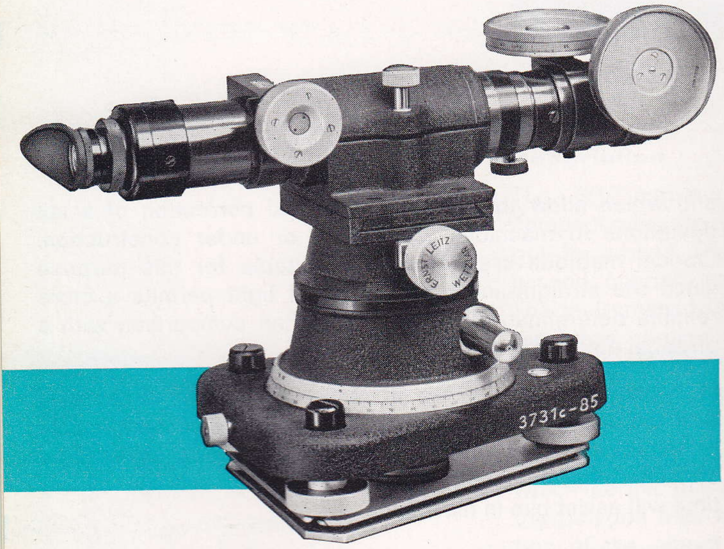
## Alignment telescope

### Examples of uses

Alignment and direction control in heavy mechanical engineering, shipbuilding, aircraft- and locomotive engineering, steel erection; alignment and measurement of baseplates, bores, bearings, guide ways etc.

### Technical data

| | | |
|---|---|---|
| Total magnification | approx. 36 x | |
| Range of the measuring attachment | ± 2.7 mm | ± 0.106″ |
| Scale unit of the measuring drums | 20 $\mu$m | 0.001″ |
| Angle measuring range of the collimator graticule | ± 30 min. | |
| Scale unit | 30 sec. | |
| Minimum sighting distance | 1 m | 40″ |
| with front lens attachment | 0.5 m | 20″ |
| Clamping diameter | 56h5 mm | 2¼ – 0.0005″ |
| Weight | approx. 3 kg | 6.6 lbs. |



### Description

During alignment testing (measurement of parallel displacements) centring collimating marks are sighted after insertion in the bore or placing on the guide track or surface to be tested. Deviations of the collimating marks from the line of sighting can be measured by means of an optical measuring attachment in rectangular coordinates.

For direction measurements (measurements of inclinations) the alignment telescope is used together with a collimator. The angle of inclination can be read directly off the collimator graticule.

Accessories are available for the various methods of measurement: – auto-collimator attachment for direction testing, front mirror and mirror with fixed measuring base, pentaprisms for the deflection of the beam path, etc.

Detailed description: – List 85–1.

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## Auto-collimator

### Technical data

| | | |
|---|---|---|
| Focal length | 500 mm | 20″ |
| Telescope magnification | 20 x* or | 40 x** |
| Measuring range | 16 min. or 30 min. | 16 min. |
| Scale unit | 0.5 sec. | 0.1 sec. |
| Free objective diameter | 58 mm 2.3″ | 58 mm 2.3″ |
| Maximum mirror distance | 30 m | 100 ft. |
| Height x width x depth | 190 x 330 x 150 mm | 7.5 x 13 x 6″ |
| Weight | approx. 16 kg | 35 lbs. |

* Eyepiece with inclination or eyepiece with diagonal division
** with diagonal division only

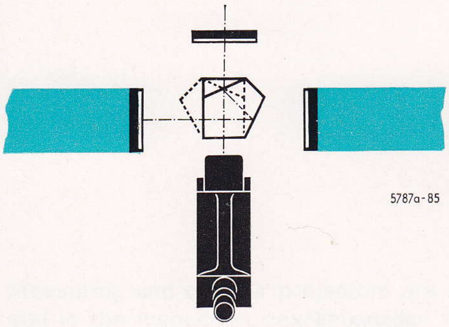
**Examples of uses**

Direction tests (measurement of angles and tilting movements independent of parallel displacements). Flatness tests on machine beds, guide ways, surface plates and alignment of machine beds. Measurement of tilts and deformations of components, out-of-true spindle rotation, tests for parallelism of bores, shafts, and planes. Alignment and measurement of the right angle on machine beds, stands, etc. Testing of circular scales and gears with the aid of polygons.

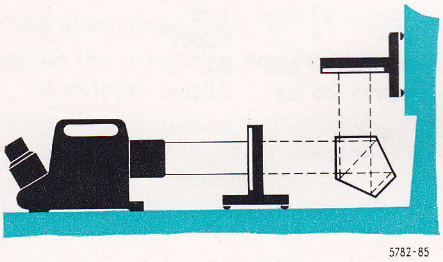
**Description**

The auto-collimator represents a combination of alignment telescope and collimator. It projects cross lines into infinity, to be reflected into the eyepiece by means of a mirror attached to the testpiece. Hence, changes in the position of the cross lines in the eyepiece correspond with changes in the angle formed by the mirror surface and the telescope. The extent of the angle changes is measured with the micrometer eyepiece. Horizontal as well as vertical angle components can be measured by rotating the micrometer eyepiece around its optical axis. A special eyepiece with diagonal division makes it possible to measure both angle components successively without rotating the micrometer eyepiece.

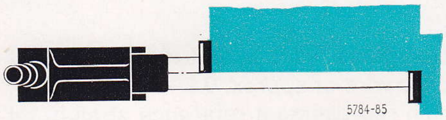
The "coiled beam-path" design results in a short overall length in spite of the long focal length of the optical system. This makes the instrument highly sensitive, yet very handy and easy to transport.



Measuring the wedge error of two parallel internal surfaces with pentaprism, 3 mirrors, and auto-collimator.



Measuring a right angle with pentaprism, mirror, and auto-collimator.



Measuring the wedge error of two surfaces with two mirrors and auto-collimator.

A number of accessories are available for the solution of the measuring problems mentioned above: –

**Plane mirror** with baseplate for the measurement of surface plates, machine beds, guide ways etc.

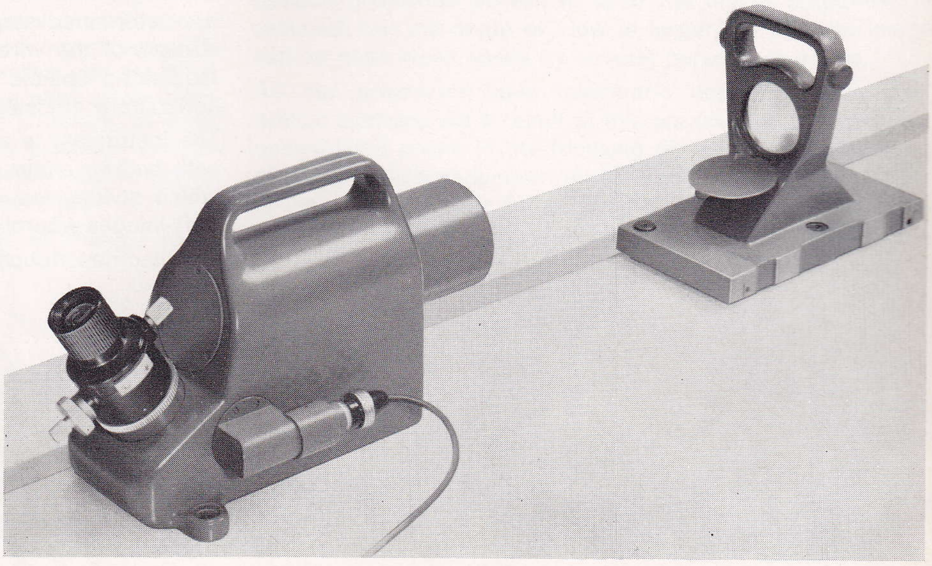
**Deflecting mirror** to deflect the beam path for the measurement of surface plates.

**Double mirror** for testing the right angle between the spindle and a movement direction, etc.

**Pentaprism** for deflecting the beam path through 90°.

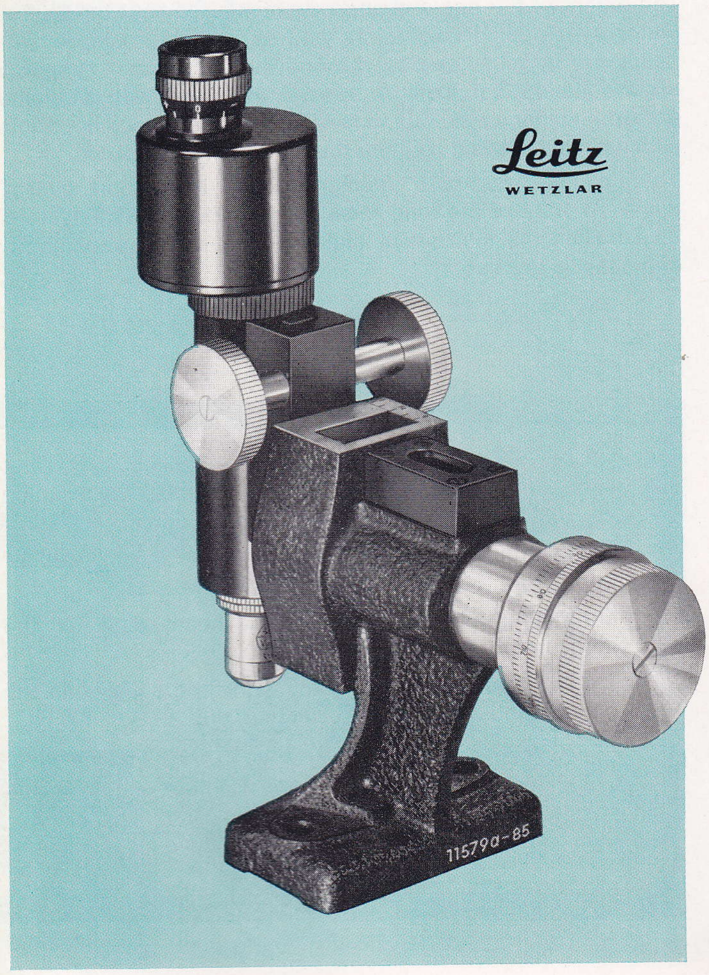
**Polygons** (p. 38) for the control of circular scales etc.

Detailed description: – List 85–3.



Auto-collimator and mirror with defined measuring base.

# Alignment microscope



### Technical data

| | | | |
|---|---|---|---|
| Total magnification | approx. 15 | x | |
| Measuring range | 20 | mm | 0.8″ |
| Object distance | approx. 37 | mm | 1.45″ |
| Scale unit of the measuring drum | 2 | $\mu$m | 0.0001″ |
| Viewing level | approx. 220 | mm | 8.7″ |
| Weight | approx. 2.5 | kg | 5.5 lbs. |

### Examples of uses

Measurement of guide ways on machine beds, etc.

### Description

For the measurement of guide ways a thin measuring wire (steel or phosphor bronze wire of approx. 0.1 – 0.3 mm [0.005″ – 0.015″] diameter) which represents a reference straight for the guide is fixed on the headstock or on a special holder. The alignment microscope is moved along the guide through pre-determined steps; any deviation of the guide from the straight of the wire can be read on the drum division of a measuring spindle after the wire has been aligned in the horizontally adjustable microscope.

The instrument is available either with a Huygens eyepiece with built-in angle graticule, or with a split-image eyepiece which divides the measuring wire into two counter-moving part-images whereby the setting tolerance is halved.

Detailed description: — List 85—7.

# 5.

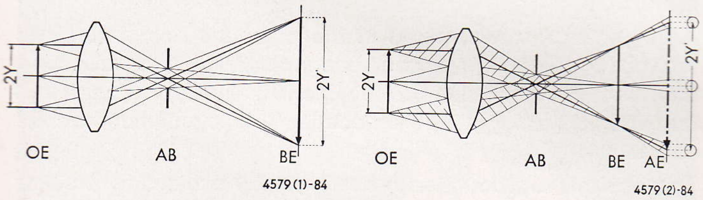
# Measuring and contour projection

Measuring and contour projectors are used in the workshop and in the inspection department for the measurement and control of shapes by means of magnified projection images.

Two alternatives exist for the measurement: — Measurement

a) on the projection screen against scales, index marks, or drawings;

b) by a measurable displacement of the testpiece on a co-ordinate measuring stage against a mark (cross lines) on the projection screen.



The two diagrams illustrate the effect of the telecentric beam path with accurate focusing (left) and out-of-focus setting (right): —

The principal rays proceeding from the left parallel to the optical axis are unchanged in both instances. With accurate focusing the projection plane AE (projection surface) is identical with the image plane BE. With out-of-focus settings the image plane is displaced, but at the same distance between object and projection plane the centre of confusion on the projection plane is preserved because the principal rays are unchanged. Hence, the distance measured from centre to centre does not depend on accurate focusing.

OE = object plane, AB = aperture diaphragm, BE = image plane, AE = projection plane.

The control of shapes is carried out either by comparison with drawings mounted on the projection surface, or, where possible, with graticules or comparison objects.

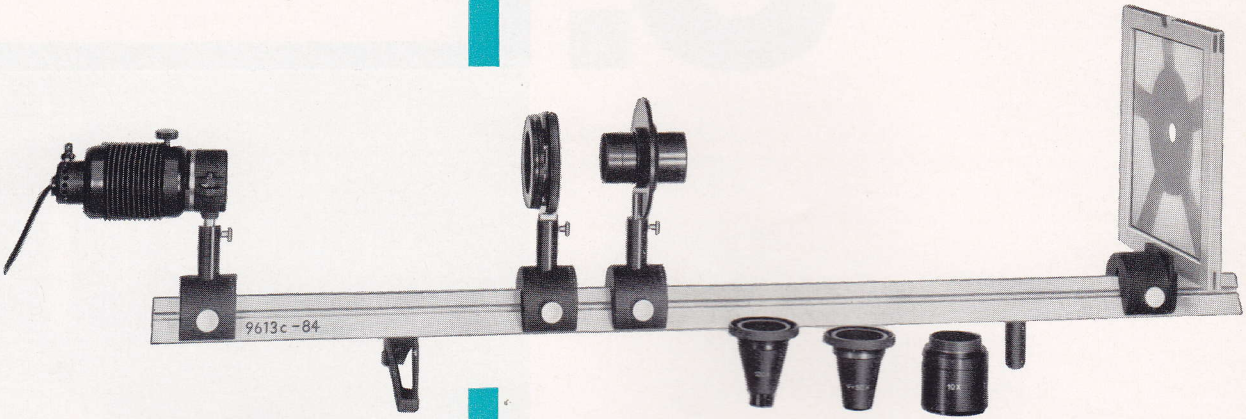
The objects to be measured are illuminated with either transmitted or incident light, or with combined transmitted and incident light according to requirements.

In transmitted light the outline of the testpiece appears as a magnified silhouette; on the projection screen incident light illumination makes it possible to recognize and to measure shoulders, index lines, engravings, blind bores, etc. The testpiece is exposed to a great light density (light rays parallel to the optical axis) so that the rays reflected from the surface form a sufficiently bright image on the projection screen.

The projected image is produced either on a translucent screen such as a groundglass screen, or on an opaque, white surface. The narrower scattering angle of the groundglass screen results in a brighter projection image, while the angle of view is narrower than the scattering angle. The beam path remains unobstructed during operation (e. g. during measurement on the projection surface). When an opaque projection screen is used the image brightness is reduced, but the angle of view is larger, so that the image can be seen more easily by several persons at a time.

All our projectors have telecentric beam paths in their optical systems. As a result of this parallel projection, small, unavoidable errors in the focusing of the testpiece have no effect on the reproduction ratio. For each instrument a number of lenses is available for different reproduction ratios; they are either individually interchangeable or mounted on a turret.

# Simple projection instrument EP



Projection instrument
with light source, central mount,
objective, and image screen;
in front: –
three additional objectives

### Technical data

| Objectives | 10:1 | 25:1 | 50:1 | 100:1 |
|---|---|---|---|---|
| Reproduction ratio at a projection distance of approx. 2.5 m | 10:1 | 25:1 | 50:1 | 100:1 |
| Maximum object field diameter for exact image | 40 mm 1.6″ | 20 mm 0.8″ | 10 mm 0.4″ | 5 mm 0.2″ |
| Length of optical bench | 1300 mm 51″ | | | |

### Description

The projection device is assembled on a prismatic bar (optical bench), on which the illuminating device, object holder, objective, and projection screen can be adjusted. A larger, independent screen or a wall can also be used for projection.

All objectives can be fixed in the objective holder and are interchangeable. For higher magnifications a microscope tube with rack-and-pinion movement is available, on which our standard microscope objectives and eyepieces can be used.

The desired reproduction ratio is set by projecting a stage micrometer and increasing or decreasing the projection distance.

Detailed description: – List 84–10.

### Examples of uses

Technical profile inspection
of gauges,
stamped parts,
tools.

# Optical bench comparator TP200

## Technical data

| | | | |
|---|---|---|---|
| Diameter of projection area | | 200 mm | 8″ |
| Reproduction ratio | 10 : 1 | 20:1 | 50:1 |
| Working distance with transmitted light approx. | 45 mm 1.77″ | 42 mm 1.65″ | 36 mm 1.42″ |
| Object field diameter | 20 mm 0.79″ | 10 mm 0.39″ | 4 mm 0.16″ |
| Range of the measuring stage | | 25 x 25 mm | 1 x 1″ |
| Height x width x depth | | 590 x 410 x 590 mm | 23 x 16 x 23″ |
| Weight | | approx. 51 kg | 112 lbs. |

## Examples of uses

Measuring and inspection of stamped parts, small gearwheels and other parts with complicated outlines occurring in the watch making and precision engineering industries. As it can be used from a sitting position, it is well suited for mass inspection.

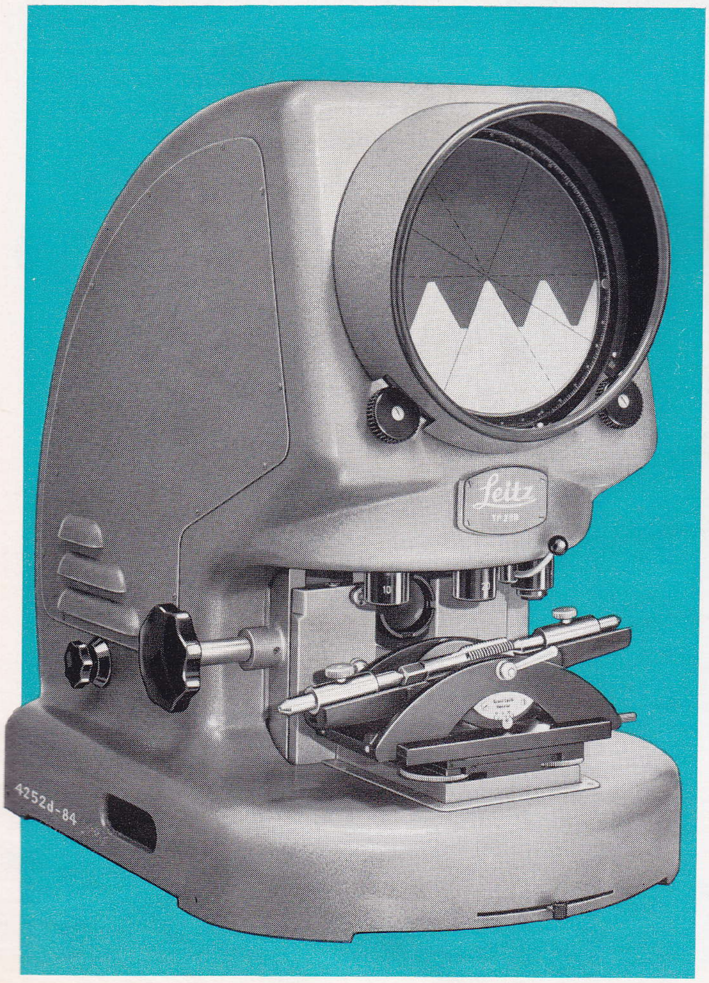
## Description

Investigations can be carried out with transmitted or whith incident light or with combined transmitted and incident light. Two independent light sources are built in for both types of illumination. Due to the highly efficient optical system the projection image is bright enough for work under daylight conditions.

The well-corrected telecentric objectives are mounted on a turret, so that the reproduction ratio is altered simply by changing the objectives. The objectives project the image of the testpiece on a ring-mounted groundglass screen which can be rotated and clamped in any position. An angle scale of 360° with a vernier scale of 4 min. accuracy is provided for angle measurements. The groundglass screen is interchangeable and can on request be supplied with built-in tolerance marks. A special clearglass disc with coverplate accommodates foils or translucent drawing paper.

The bench comparator can be equipped with various object stages and mounting devices for special purposes. A special objective for transmitted light can be used for the 100 : 1 reproduction ratio.

Detailed description: — List 84 — 1.



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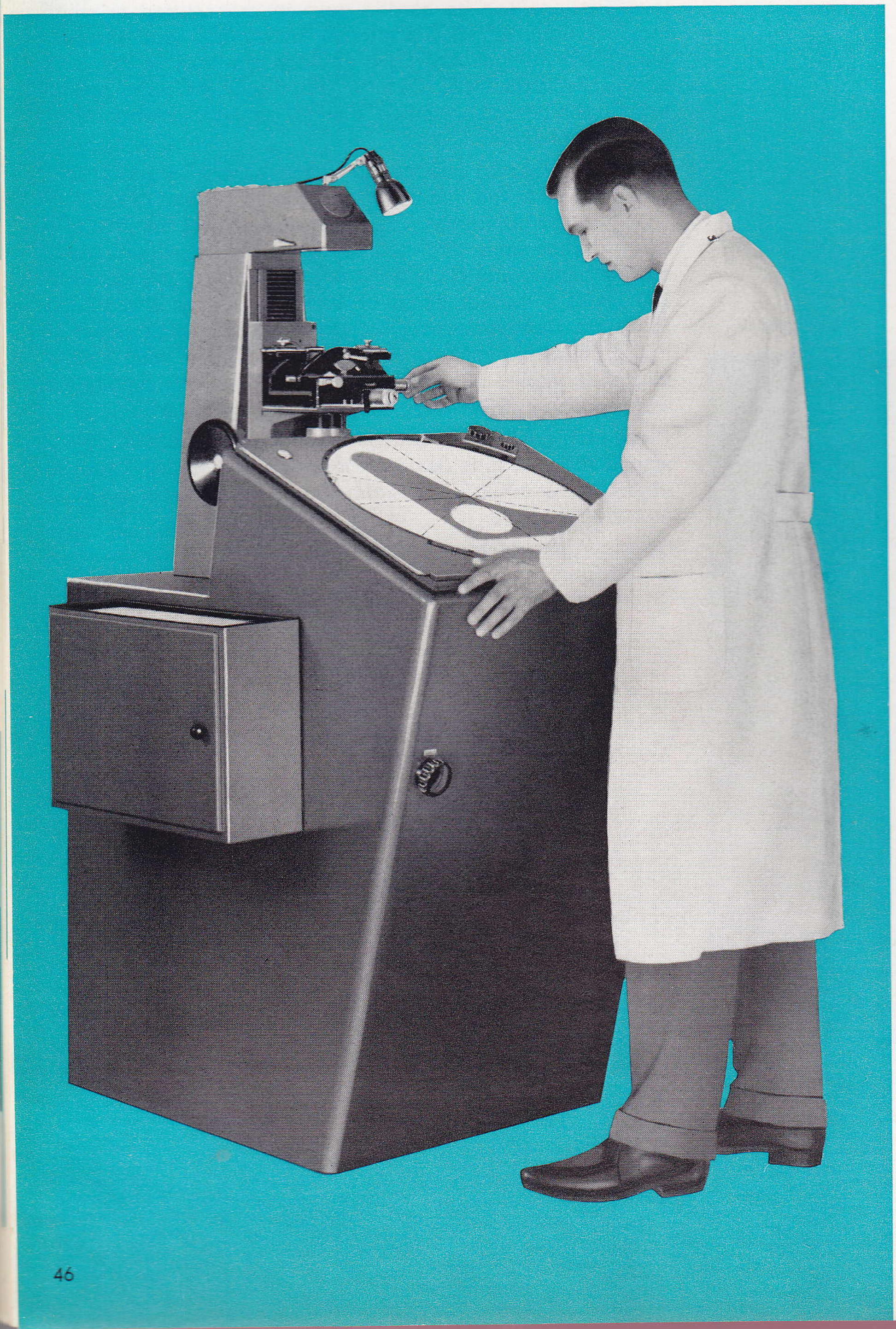
# Contour measuring projector PP 500

### Technical data

| | | | | |
|---|---|---|---|---|
| Size of projection area | 500 x 500 mm 20 x 20″ | | | |
| Reproduction ratio | 10:1 | 20:1 | 50:1 | 100:1 |
| Object field diameter | 50 mm 2″ | 25 mm 1″ | 10 mm 0.4″ | 5 mm 0.2″ |
| Free working distance in transmitted light approx. | 130 mm 5.1″ | 110 mm 4.3″ | 46 mm 1.8″ | 20 mm 0.8″ |
| Height x width x depth | 1750 x 650 x 1250 mm 69 x 26 x 50″ | | | |
| Weight | approx. 250 kg 490 lbs. | | | |



### Examples of uses

Projection measuring instrument for inspection department and workshop; for the determination of shapes, checking of lengths, angles, and radii on stamped parts, milling cutters, gearwheels, tools, etc.

### Description

The contour measuring projector PP 500 is a robustly designed, simply operated instrument with a large projection area and excellent optical qualities. It can be used for transmitted-light and incident-light examination, and its image is so bright, that screening from room- or daylight is necessary for high magnifications only. The beam path is telecentric; small errors in focusing have therefore no effect on the reproduction ratio.

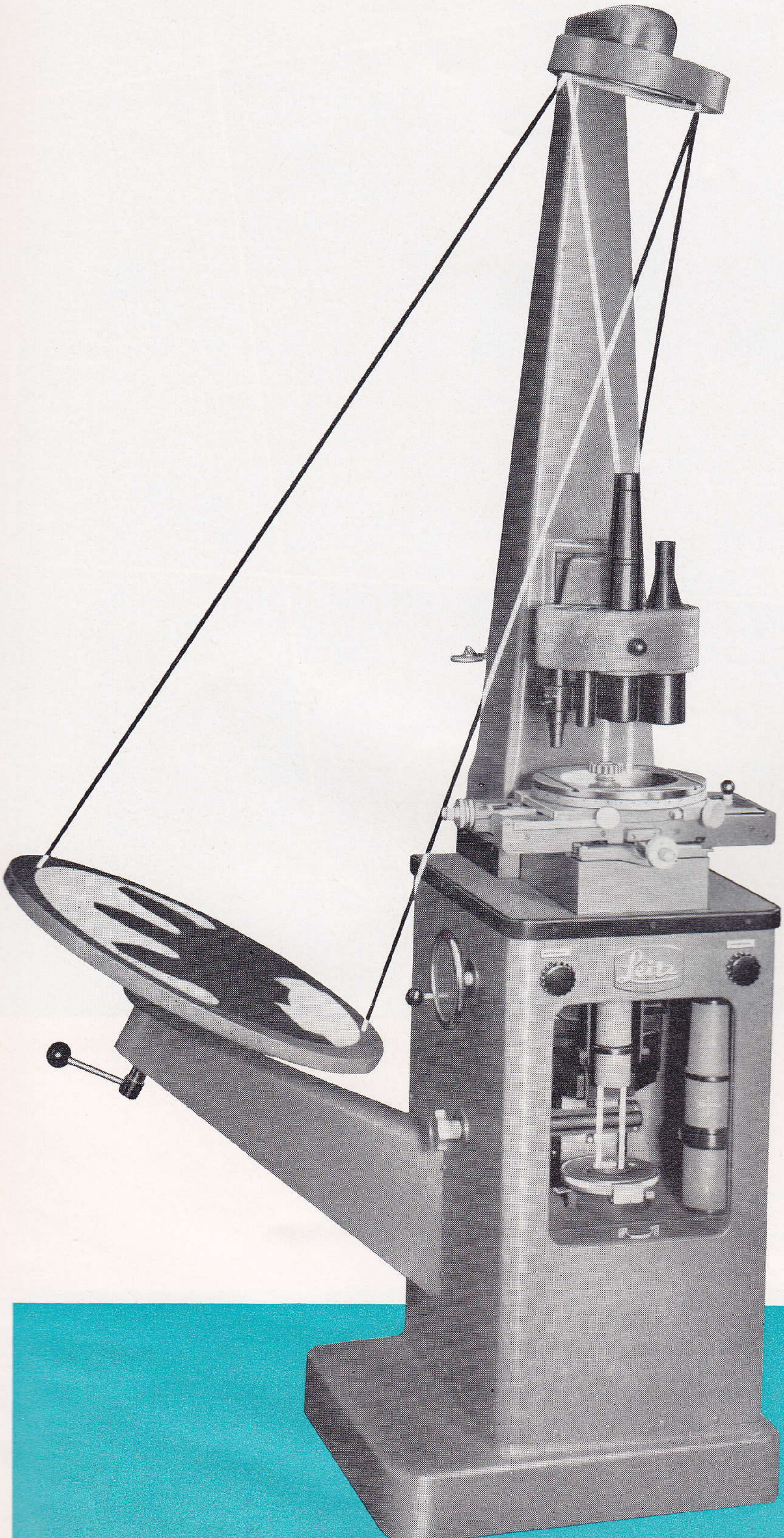
The projection screen which can also be supplied in a rotating or fixed mount with angle division and vernier scale is interchangeable. Various object stages and mounting devices are available.

Detailed description: – List 84 – 9.

# Large contour measuring projector GP 650

### Technical data

| | | | | |
|---|---|---|---|---|
| Diameter of projection screen | 650 mm 25.6″ | | | |
| Reproduction ratio | 10:1 | 20:1 | 50:1 | 100:1 |
| Object field diameter | 65 mm 2.6″ | 32.5 mm 1.3″ | 13 mm 0.51″ | 6.5 mm 0.26″ |
| Free working distance | 170 mm 6.7″ | 155 mm 6.1″ | 65 mm 2.5″ | 31 mm 1.2″ |
| Height x width x depth | 2750 x 1400 x 1000 mm | 110 x 55 x 40″ | | |
| Weight | approx. 685 kg | 1500 lbs. | | |



### Examples of uses

Projection measuring instrument for inspection department and workshop, particularly for checking gauges and tools.

### Description

In addition to the general characteristics common to all our projectors – such as excellent quality and brightness of the projected image, telecentric beam path, transmitted- and incident-light illumination – this projector has a particularly large projection area and a correspondingly large object field for the various reproduction ratios, interchangeable by means of a turret with four objectives.

The built-in intermediate image system makes it possible to compare testpieces with graticule drawings or comparison objects. The image of a graticule drawing is formed in the object plane and projected on to the projection screen together with the image of the testpiece. Here, too, the objects to be measured can be compared on the projection screen with a drawing made at the same reproduction ratio. A mechanical measuring stage with built-in rotating stage (p. 28) permits the measurement of the testpiece. Various mounting devices can be fixed on the surface of the measuring stage.

Detailed description: – List 84 – 2.

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**Examples of uses for contour projectors**

# 6. Surface- and roughness testing

The technical surface structure is gaining more and more importance in industrial manufacturing processes and in metrology.

It is being realized to an ever-increasing extent that knowledge of the surface provides information of considerable effect on industrial performance and production.

Due to its three-dimensional structure and the overlapping of macro- and micro-geometry, the measurement of surfaces is considerably more difficult than, say, the determination of linear values. Standards which have recently been introduced have clarified conditions sufficiently for providing theoretical as well as practical workers with guidance on a standardized terminology, and on the design of measuring instruments.

Thus, DIN Standard 4760 deals with the terms for surface shape, DIN 4761 with those for surface character, DIN 4762 lays down the terms for 2nd–5th order deviations from standard, and DIN 4763 determines the orders of measurements of the roughness of a surface.

Even this description shows that the surface of a workpiece cannot be defined exactly by means of a single factor; several values are necessary for its assessment. Thus, roughness depth Rt in $\mu$m has been introduced as a measure of the microstructure (fine structure). It represents the distance between the highest and lowest points of a surface profile. Other characteristic values for the micro-structure are, for instance, the arithmetical mean roughness value Ra and the smoothness depth Rp, both clearly defined by DIN 4762.

However, in order to be able to judge a surface it is not sufficient to know its micro-structure; data must also be available on the macro-geometrical or coarse structure. The micro-structure deals with the shape of the surface of the section of an object. Here, roughness and undulations of an object are determined. The coarse structure is the surface shape of a technical object seen geometrically as a whole. It reveals any irregularities, faulty shape, etc.

The task of a surface measuring instrument is to measure several of these standardized characteristics. It is important to be able to measure the micro- as well as the macro-structure of an object. The range of instruments available to-day is very extensive. According to their purpose they can be divided into workshop or inspection department instruments, and according to their measuring method into mechanical-optical scanning devices, optical instruments based exclusively on the action of light, and electrical and pneumatic surface measuring instruments.

## Optical flats

### Technical data

| | | | |
|---|---|---|---|
| Size I | Diameter | 45 mm | 1.8″ |
| | Thickness | 15 mm | 0.6″ |
| Size II | Diameter | 60 mm | 2.4″ |
| | Thickness | 20 mm | 0.8″ |
| Maximum deviation from flatness | | | |
| | Quality 1 | ± 0,1 µm | ± 0.000004″ |
| | Quality 2 | ± 0,2 µm | ± 0.000008″ |

### Examples of uses

Examining the smoothness of lapped and polished metal and glass surfaces, e.g. measuring surfaces of measuring spindles, contact tips, gauges, and slip gauges.

### Description

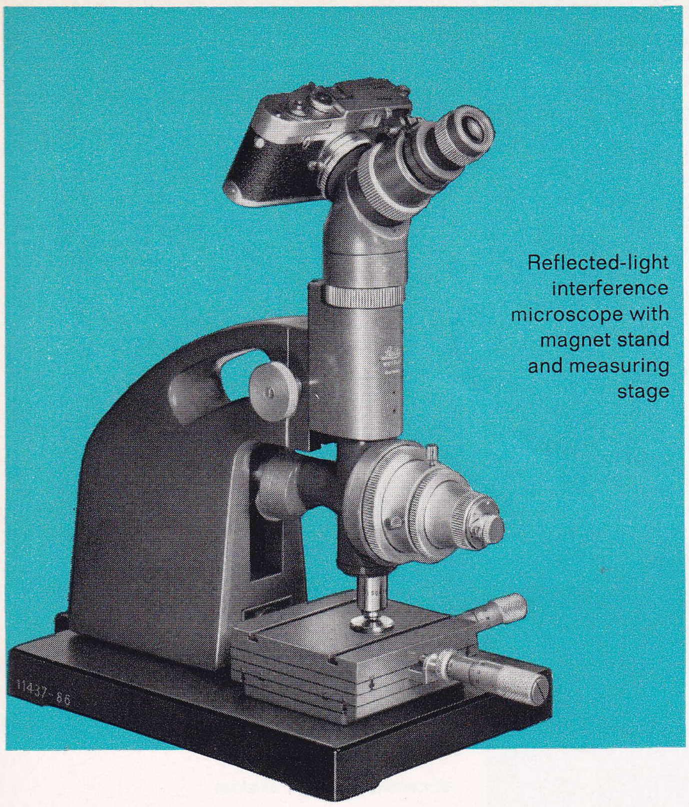
The flatness of the measuring surfaces is examined with the aid of the interference phenomenon. After the plane glass plate has been placed on the surface to be examined interference bands are caused which connect all points on the surface situated at the same level (topographical map); hence, geometrical faults of the surface are revealed by the shape of the interference bands. The extent of the faults can be calculated from the curvature of the bands. A special illuminating device is provided for investigations in monochromatic light.

Detailed description: — List 71—2.

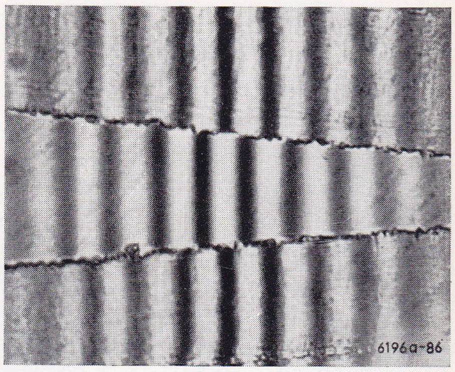
## Reflected-light interference microscope

### Technical data

| | | | | | | |
|---|---|---|---|---|---|---|
| Magnification | 100 x | | 200 x | | 500 x | |
| Aperture | 0,18 | | 0.35 | | 0.85 | |
| Object field diameter | 1.52 mm | 0.06″ | 0.76 mm | 0.03″ | 0,3 mm | 0.012″ |
| Working distance | 13 mm | 0.51″ | 1.2 mm | 0.047″ | 0.3 mm | 0.012″ |
| Measuring range | approx. 0.03 . . . 30 µm | | 0.0000012 . . . 0.0012″ | | | |
| Height x width x depth | 550 x 400 x 300 mm | | 22 x 16 x 12″ | | | |
| Weight | approx. 41 kg | | 90 lbs. (with upright) | | | |



Reflected-light interference microscope with magnet stand and measuring stage



Microtome section placed on black glass. The interferences (white light) of the section are displaced by $\lambda/4$; this corresponds with a section thickness of about 0.14 $\mu$m (0.0000055″)

**Examples of uses**

Testing of precision-worked surfaces, measurement of thicknesses of layers, small differences in length, minute inclinations; comparative thickness measurements.

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**Description**

While profile lines can be revealed by mechanical tracing, the interference instrument measures portions of an area. The lower limit of the measuring range with roughness depths, steps, etc. is 0.03 $\mu$m; the upper limit depends on the quality of the surface and on how the sample was prepared. With the aid of film replicas or lacquered imprints the range can be extended up to 30 $\mu$m and beyond.

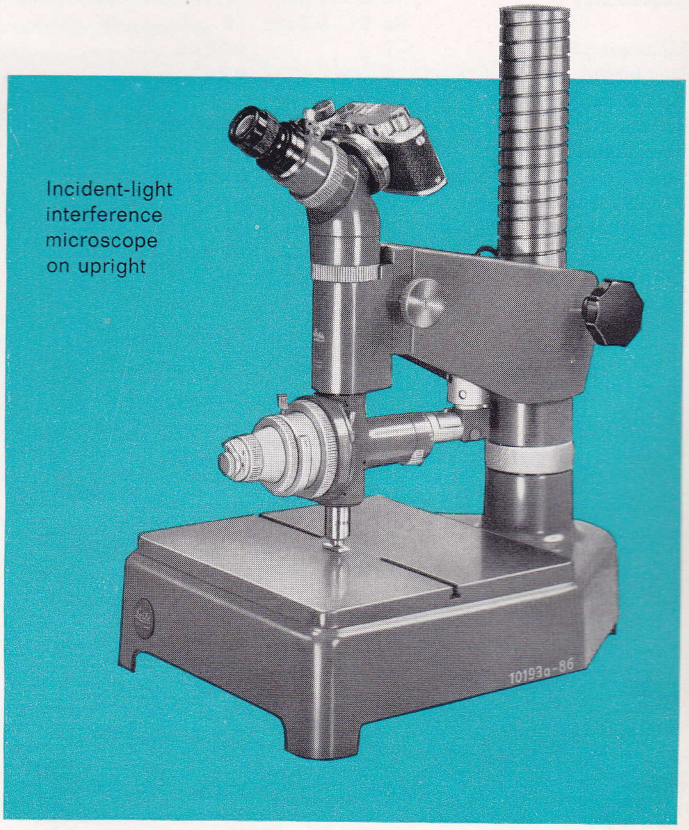
The LEITZ reflected-light interference microscope operates on the Michelson dual beam principle. It is equipped with interchangeable paired objectives. Width and direction of the interference bands can be set as required according to the surface structure. An adjustable comparison mirror with two reflecting sectors (approximately 5% and 70% reflection) is fitted in front of the comparison objective; it can be adjusted to the reflection of the surface to be tested, so that good contrast of the interference bands is ensured.

White as well as monochromatic light can be used; the monochromatic light is produced by means of a swing-out interference filter.

Our well-known LEICA 35 mm camera is available for photographic recording.

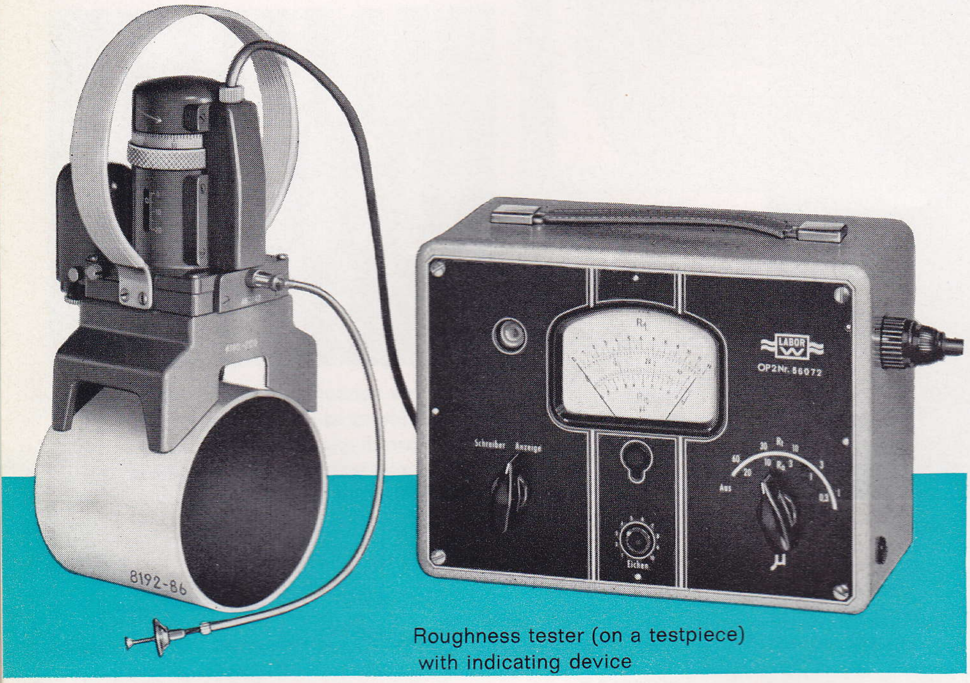
On request the reflected-light interference microscope can be supplied with a directly attachable magnetic stand also for large objects, and with upright for objects of 264 mm maximum height.

Detailed description: — List 86—6.



Incident-light interference microscope on upright

# Surface roughness tester



Roughness tester (on a testpiece) with indicating device

### Examples of uses

Measurement of the roughness depth Rt and the arithmetical mean roughness value Ra (suitable mainly for random measurements).

### Technical data

| | | | | | | |
|---|---|---|---|---|---|---|
| Measuring range (adjustable) | Rt | 0…1 µm | 0…3 µm | 0…10 µm | 0…30 µm | 0…60 µm |
| | Ra | 0…0.3 µm | 0…1 µm | 0…3 µm | 0…10 µm | 0…20 µm |
| Measuring force | < 7 | g | 0.25 oz. | | | |
| Test length | 6 | mm | 0.24″ | | | |
| Rate of movement (adjustable) | normally 1 | mm/sec. | 0.04″/sec. | | | |
| Point radius of stylus | approx. 15 | µm | 0.0006″ | | | |
| Height x width x depth | | | | | | |
| with prismatic base | | 245 x 165 x 80 mm | 9.6 x 6.5 x 3.2″ | | | |
| with stand | | 550 x 400 x 300 mm | 22 x 16 x 12″ | | | |
| Weight with stand | approx. 50 | kg | 110 lbs. | | | |

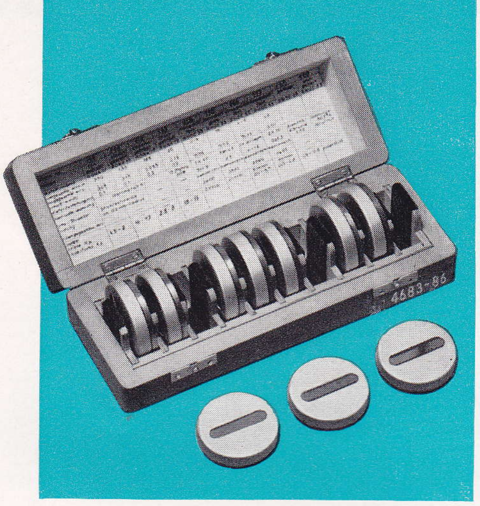
### Description

The roughness tester consists of a tracing instrument with an inductive transmitter and an amplifier with indicator. Recording devices (maximum amplification 30,000) can be attached. By means of interchangeable supports the tracing instrument can be placed on testpieces with cylindrical and plane surfaces. A universal stand has been provided for the examination of small parts. In connection with an internal tracing device bores above 6 mm (0.25″) diameter can be measured to a depth of 20 mm (0.8″), and above 9 mm (0.36″) diameter to a depth of 30 mm (1.2″).

The tracing head is mounted on a slide guided on an optically plane lapped surface. By means of a release the stylus is lifted, the tracing head advanced, and the springs wound for the return movement during which the roughness is measured. An adjustable oil brake maintains constant speed. During the tracing of a surface the stylus is moved up and down through the roughness of the surface; these movements induce potentials in a moving coil system which indicate the roughness value in µm on the indicator through an amplifier.

Detailed description: — List 86—4.

# Comparison specimens for technological surface inspection



**Technical data**

| | | | |
|---|---|---|---|
| Size of test surface | 7 x 30 | mm | 0.28 x 1.2″ |
| Rt | approx. 0.1 ... 16 | μm | 0.000004 ... 0.0006″ |
| Ra | approx. 0.07 ... 4.5 | μm | 0.0000028 ... 0.00018″ |

**Examples of uses**

Calibrating of our surface roughness tester.

**Description**

The individual comparison specimens of the set (10 pieces) have been manufactured by various finishing processes. They are turned, milled, ground, or lapped at different Rt and Ra values parallel to the polished support surfaces. A test chart is enclosed with the storage box giving details of the roughness depths and finishing methods of the individual comparison specimens.

Detailed description: — List 86—3.

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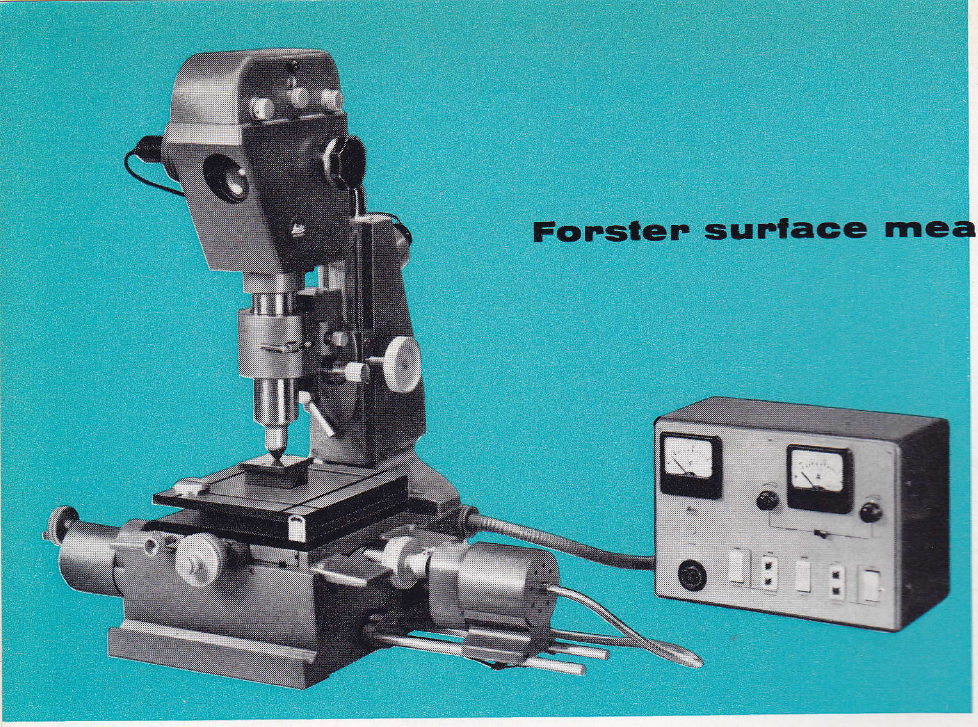
# Forster surface measuring instrument



LEITZ Surface measuring Instrument
after Forster with control unit

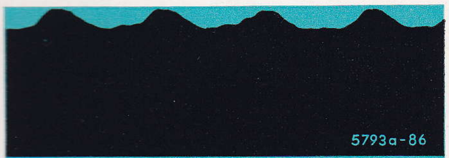
## Technical data

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| Measuring range Rt | 0.2 ... 100 µm |  |  |  |  |
| Maximum test length | 100 mm 4″ |  |  |  |  |
| Magnification vertical | 250:1 |  | 1000:1 |  | 2500:1 |
| horizontal | 20:1 | 25:1 | 33:1 | 100:1 | 1000:1 |
| Workpiece feed | 5 mm/min. 0.2″/min. | 4 mm/min. 0.16″/min. | 3 mm/min. 0.12″/min. | 1 mm/min. 0.04″/min. | 0.1 mm/min. 0.004″/min. |
| Recording strip feed | 100 mm/min. 4″/min. |  |  |  |  |
| Measuring pressure | < 1 g 0.035 oz. |  |  |  |  |
| Point radius of stylus | 10 µm 0.0004″ (2 µm 0.00008″ on request) |  |  |  |  |
| Size of stage | 200 x 200 mm 8 x 8″ |  |  |  |  |
| Height x width x depth | 600 x 730 x 430 mm 24 x 29 x 17″ |  |  |  |  |
| Weight | approx. 50 kg 110 lbs. |  |  |  |  |

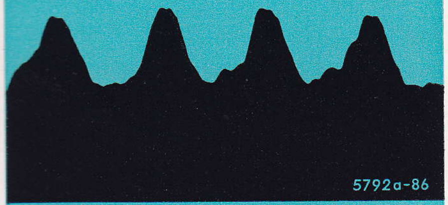
## Examples of uses

Contour section instrument for research purposes and industrial laboratories; for micro- and macro-geometrical investigations.

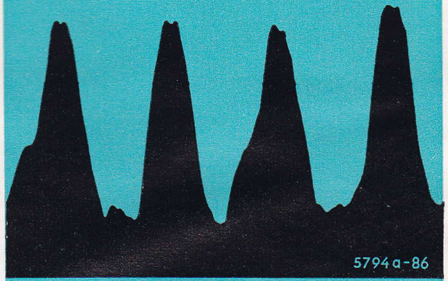
Profile records of a
single-tooth milled surface, horizontal
magnification 100 : 1 throughout



Vertical magnification 250 : 1



Vertical magnification 1000 : 1



Vertical magnification 2500 : 1

## Description

The Forster surface measuring instrument is a profile section device adapted to the metrological specifications of DIN. It offers the special advantage of determining form deviations of an object in addition to its roughness. During the measuring process a mechanical tracer with stylus traces the surface of the workpiece moving under it. The vertical differences of the profile shape are magnified mechanically and optically and indicated on a ground-glass screen or recorded by means of a recording device. During the tracing of a surface the stylus pulsates at 50 or 100 c/s as required. This produces only small forces on the stylus vertical to its axis, so that sapphire styluses with minimum point radii and "high resolving power" can be used.

The stage — with a choice of various speeds — can be tilted and adjusted transversely to its movement which is limited by electrical switch-offs.

Attachments are available for the tracing of vertical surfaces and bores.

A Copyrapid developing unit for immediate development of the recording strips forms part of the accessory range.

Detailed description: — List 86 — 1.

# 7.

# Hardness testing

Hardness is one of the most important technological characteristics affecting the operational quality and durability of a workpiece. Scratch hardness testing represents the oldest hardness test method; it was used by Mohs to establish a hardness scale for minerals. The scratch test is used even to-day — although under improved conditions — in order to obtain comparison values providing information on workability and resistance to abrasion. Conical diamonds with 90°, 120°, and 150° angles of aperture, are used in addition to pyramidal scratch diamonds with 120° surface angle.

Technology usually defines hardness as the resistance offered by a body to its penetration by another body. This penetration hardness can be measured according to standardized procedures.

Of the existing hardness test methods based on the principle of penetration of one body by another only the Vickers- and Knoop hardness tests are mentioned here, since these permit tests even with small loads. According to the weight of the load imposed during the test they are divided into the following groups: —

| | |
|---|---|
| Macroload hardness test | $> 2$ kg |
| Miniload hardness test | 0.2 . . . 2 kg |
| Microload hardness test | 0 . . . 0.2 kg |

While the indentations produced by macro-hardness tests are so large as to make non-destructive tests on functional surfaces impossible, miniload and microload hardness tests allow non-destructive material examination in almost every case, so that tests are possible in mass production. Miniload tests are preferably carried out on thin foils, small and extremely small components and on surface layers. Hardness measurements of galvanized surfaces are of special importance to-day. These measurements not only reveal the surface hardness of elements which are treated galvanically to protect them from heavy wear; they also show the quality of the galvanic bath for which hardness is a very sensitive criterion.

For the Vickers determination of hardness an indentation is produced by a diamond pyramid and measured optically. The Vickers pyramid has a square base. The apical angle between opposite pyramid sides is 136°. The depth of penetration approximates one seventh part of the indentation diagonal. Vickers hardness (HV) is defined by

$$HV = \frac{1854.4 \cdot P}{d^2} \; [\text{kg/mm}^2]$$

where $P$ = indenting load [g]
$d$ = diagonal of indentation [$\mu$m]

Hardness testing according to Knoop is similar to the Vickers method. The Knoop pyramid has a rhombic base. The longitudinal and transverse diagonals of this area are as 7 : 1. The depth of penetration amounts to about $^1/_{30}$ of the longitudinal diagonal. The angles of the pairs of opposite edges are 172° 30′ and 130°. Owing to the shallow depth of penetration Knoop hardness testing is preferable for very thin surface layers, and, owing to the large indentations for hard materials.

Knoop hardness (HK) is defined by

$$HK = \frac{14\,230 \cdot P}{l^2} \; [\text{kg/mm}^2]$$

where $P$ = indenting load [g]
$l$ = long diagonal [$\mu$m]

Tables are available for the determination of hardness values, stating hardness in terms of the length of the indentation diagonal and the load applied.

## Brinell magnifiers

### Technical data

| | | |
|---|---|---|
| Magnification | 6 x | 8 x |
| Measuring range | 20 mm 0.8″ | 10 mm 0.4″ |
| Scale unit | 0.1 mm 0.005″ | 0,1 mm 0.005″ |
| Diameter of the support area | 40 mm 1.6″ | 32 mm 1.3″ |

### Examples of uses

Measurement of Brinell indentations, grooves, width of slots, small bore diameters, line widths and -intervals, thread distances in fine fabrics.

### Description

The Brinell magnifier is placed on the object to be measured and the length of measurement read off the scale engraved in the base of the magnifier.

The magnifier is corrected for colour and distortion, producing an undistorted image. It can be adjusted in a sleeve for adaptation to the user's eyesight. The measuring surface of the holder is inclined and matt chromium finished in order to ensure readings free from glare.

## Measuring microscope MZ

Leitz
WETZLAR

### Technical data

| | MZ 25 | MZ 50 |
|---|---|---|
| Magnification | 25 x | 50 x |
| Object field diameter | 9 mm 0.36″ | 4.5 mm 0.18″ |
| Measuring range | 7 mm 0.28″ | 3.5 mm 0.14″ |
| Scale unit | 0.05 mm 0.002″ | 0.025 mm 0.001″ |
| Diameter of support surface | 42 mm* 1.7″ * | |
| Weight approx. | 0.3 kg 0.7 lbs. | |

* With special base 20 mm (0.8″)

### Examples of uses

Measurement of Brinell indentations, line widths and -intervals, grooves, widths of slots, bore diameters; examination of fabrics.

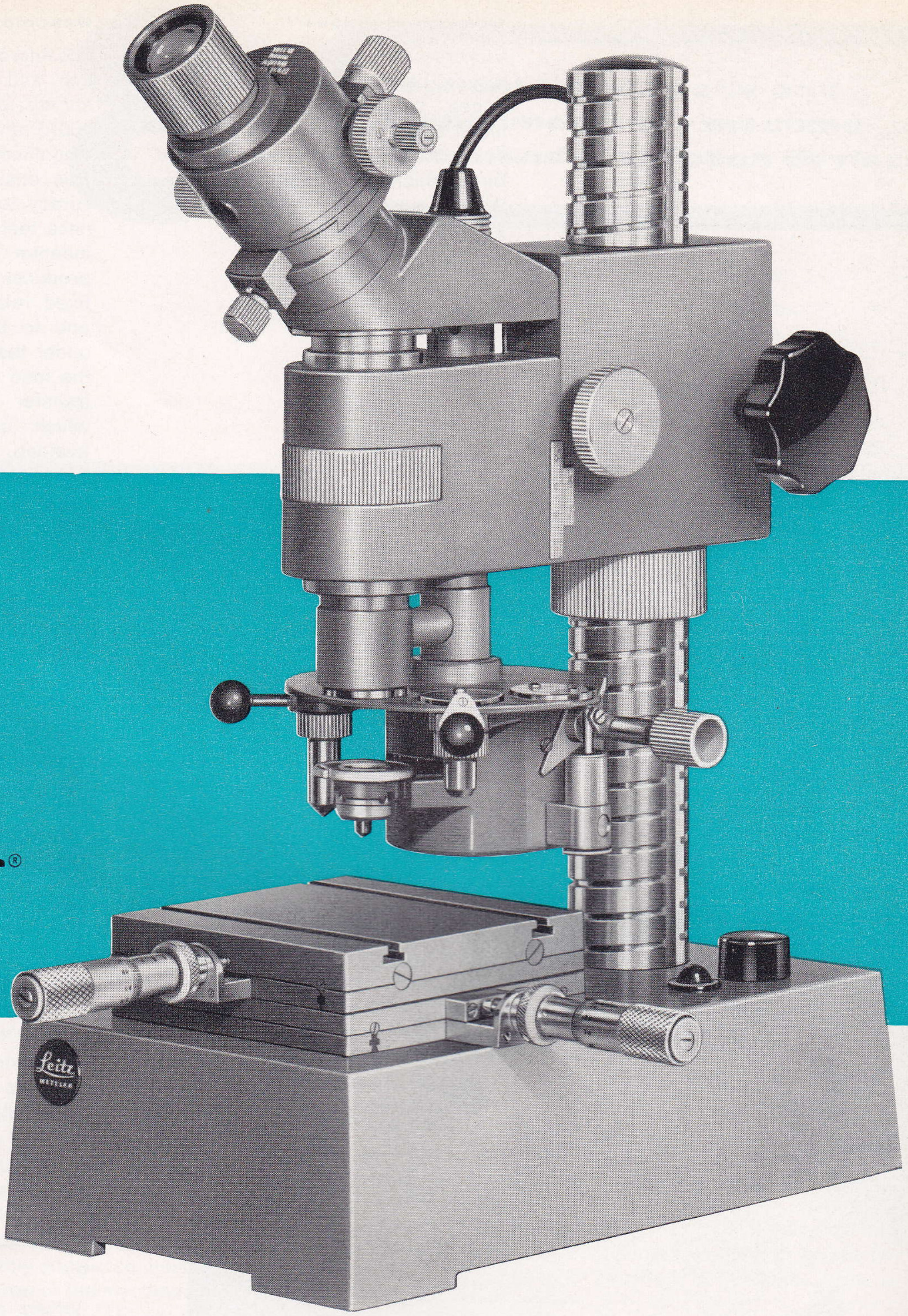
### Description

The microscope moves inside a tubular base, and engages in its working position. A fine adjustment is built in for accurate focusing. The microscope is corrected for distortion.

The scale for the determination of the measuring distance is situated in the intermediate image plane; it can be focused with the correction mount of the eyepiece. The standard model has a tube of 25 x magnification, which can be interchanged without difficulty against the 50 x tube. In both cases an incident-light illuminator can be attached.

Detailed description: – List 72 – 2.

## Miniload hardness tester®



**Technical data**

| | | |
|---|---|---|
| Indenting load | 15 . . . 2000 g | |
| Magnification | 100 x | 400 x |
| Objective aperture | 0.18 | 0.7 |
| Free working distance | 12.7 mm 0.5″ | 0.2 mm 0.008″ |
| Scale unit of the micrometer eyepiece | 0.5 µm | |
| Height x width x depth | 500 x 400 x 300 mm | 20 x 16 x 12″ |
| Weight | approx. 20 kg | 44 lbs. |

**Examples of uses**

Vickers-, Knoop-, and scratch hardness testing; hardness measurements of tool edges, thin surface layers, polished metal sections, wires, etc. Special models for hardness measurements of thread flanks or stepped parts.

With a magnetic base it can also be attached to large workpieces.

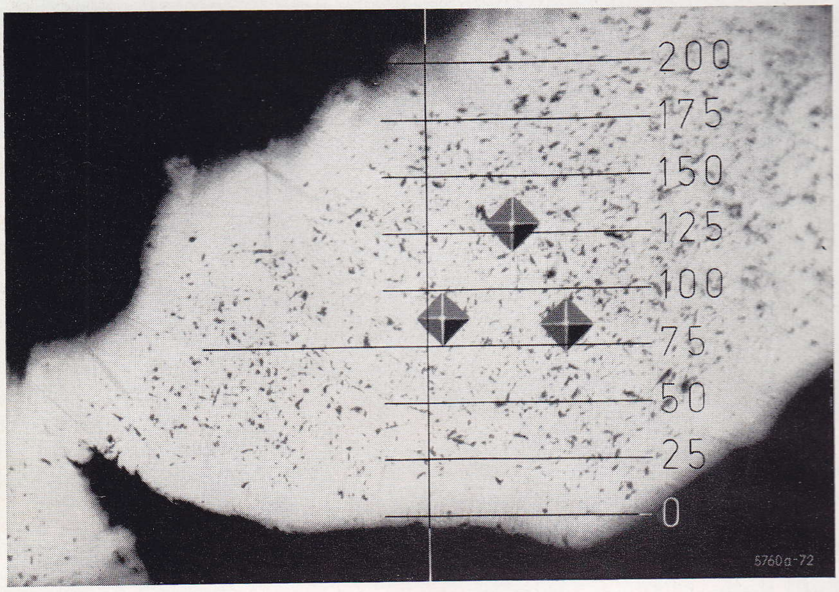
**Description**

The microscope for sighting and evaluation and the turret — with indenter, survey objective (total magnification 100 x) and evaluating objective (total magnification 400 x) — constitute a unit. This ensures sighting and aiming accuracy to the extent of allowing hardness tests on the tips of needles. The indenter (Vickers- or Knoop diamond) produces an indentation which has a fixed relationship to the load applied and to the hardness of the material under test. By the direct application of the load on the indenter errors due to transfer or transmission mechanisms which are difficult to control are avoided.

The movement of the indenter is initiated by means of a cable release, the rate of descent is determined by an adjustable oil brake. The holder of the indenter has a shear compensation which avoids lateral deformations of the indentations. An optical micrometer eyepiece permits accurate evaluation of the hardness indentations; at a scale unit of 0.5 µm, 0.1 µm can still be estimated.

Mounting devices for workpieces of various shapes and sizes are available. The LEICA® 35 mm camera can be used for recording purposes.

Detailed description: — List 72—1.



Vickers indentations on the tooth of a zip fastener.
The indentations are smaller than 25 µm (exact evaluation with the micrometer eyepiece).

# 8. Optical installations and attachments for machine tools and inspection devices

The demands for higher accuracy and rational production of workpieces has forced the manufacturers of machine tools to improve the guide ways and the control and setting elements of their machines and to adopt new methods of design.

Here, the structural devices well known from optical precision measuring techniques for the setting and control of machines are now used to a considerable extent.

In mechanical engineering and the setting up of heavy machinery two basic types of optical systems must be distinguished: — those for **installation in,** and those for **attachment to,** machines.

In machine tools of which a high degree of accuracy is required the optical structural elements, particularly the groups of scales and objectives, should be located where conditions for measuring are most favourable. Here we speak of built-in optical systems. Almost invariably allowance must already be made for them at the design stage of the machine.

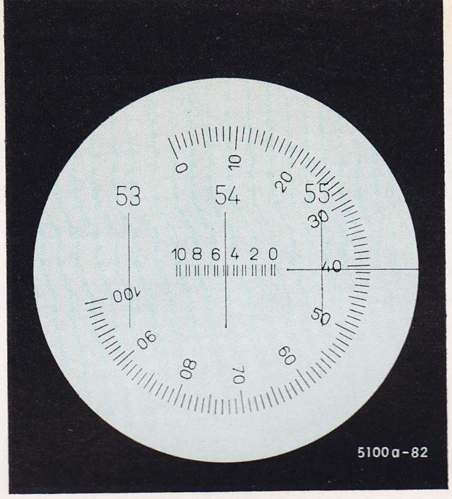
Attachable optical systems, on the other hand, can in most cases be built onto machines which were not originally designed for optical aids at any time. It entirely depends on the degree of accuracy required.

Hence, optical setting devices are prefered whenever the setting accuracy of the machine spindles is no longer sufficient for longitudinal, transverse, and vertical adjustment of the machine slides; their measuring element is a metal or glass scale with an expansion coefficient similar to that of steel. The images of the scale divisions can be focused in the eyepiece or in the projection window of a precision measuring unit with the aid of an optical system. Projection reading is gaining more and more ground in this field. However, not only scale readings, but also setting, sighting, alignment and measuring telescopes and auto-collimators, as well as the appropriate microscopes become necessary in mechanical engineering to an ever-increasing extent.

For the automatic control of machines optical-electrical incremental angle and linear transducers working in combination with electronic units and punched- or magnetic tape are available.

The field of applied optics in mechanical engineering has become so vast, that it can be discussed in general outline only within the framework of this publication.

# Scale reading microscope with screw micrometer eyepiece



Field of view of a screw micrometer eyepiece; value shown: – $54.540^5$ mm.

### Technical data

| | | | |
|---|---|---|---|
| Microscope magnification | 50 x | | |
| Eyepiece scale unit | 1 µm | 0.00005″ | |
| Clamping diameter | 38h6 mm | | |
| Objective - scale distance | approx. 36 mm | 1.4″ | |
| Scale (length as required) | | | |
| Maximum length of single scale | 1200 mm | 47″ | |
| Scale division | 1 mm | 0.05″ | |
| Glass scale | flat section 20 x 30 mm | 0.8 x 1.2″ | |
| Expansion coefficient $\alpha_{20}$ | 8.3 or 11.7 x $10^{-6}$ / °C | | |
| Aggregate scale error | max. 3 µm / m * | 0.00012″/40″ * | |
| Metal scale | a flat section 20 x 20 mm | 0.8 x 0.8″ | b H-profile |
| Expansion coefficient $\alpha_{20}$ | 11.5 x $10^{-6}$ / °C | | 11.5 x $10^{-6}$ / °C |
| Aggregate scale error | max. 3 µm / m * | 0.00012″/40″ * | |

* more accurate on request

### Examples of uses

Reading of scales
on machine tools
and inspection devices.

### Description

The microscope can be used in combination with metal- or glass scales as a complete reading device for horizontal or vertical fitting. The objective forms an image of the millimetre division of the scale in the graticule plane of the screw micrometer eyepiece, which permits the focusing or reading of a certain value in the field of view. A zero setting is provided for the setting of integral starting values.

The divisions and figures of transparent glass scales are illuminated by transmitted light, the divisions and figures of metal and silvered glass scales by means of an incident-light illuminator; they are projected into the graticule plane of the screw micrometer eyepiece. The incident-light illuminator can be provided for scales aligned vertically or parallel to the optical axis. It is fitted with a semi-transparent plane glass plate.

The maximum scale length is 1.2 m (48″). For greater lengths 1 m (40″) scales appropriately numbered are arranged end-to-end.

# Optical installation for linear or angle readings

## Technical data

| | | |
|---|---|---|
| Magnification | approx. 45 x | |
| Scale unit for linear measurement | 1 $\mu$m | 0.00005″ |
| Scale unit for angle measurement | 2 sec. | |
| Glass scale | | |
| maximum length of single scale | 1.2 m* | 47″ * |
| Flat section | 20 x 30 mm | 0.8 x 1.2″ |
| Scale division | 1 mm | 0.05″ |
| Aggregate scale error | max. 3 $\mu$m / mm ** | 0.00012″/40″ ** |
| Expansion coefficient $\alpha_{20}$ | 8.3 or 11.7 x $10^{-6}$ / °C | |

* Shorter scales on request

** More accurate on request

## Examples of uses

For installation in machine tools and inspection devices, for the setting and reading of machine positions and rotating stages, etc.

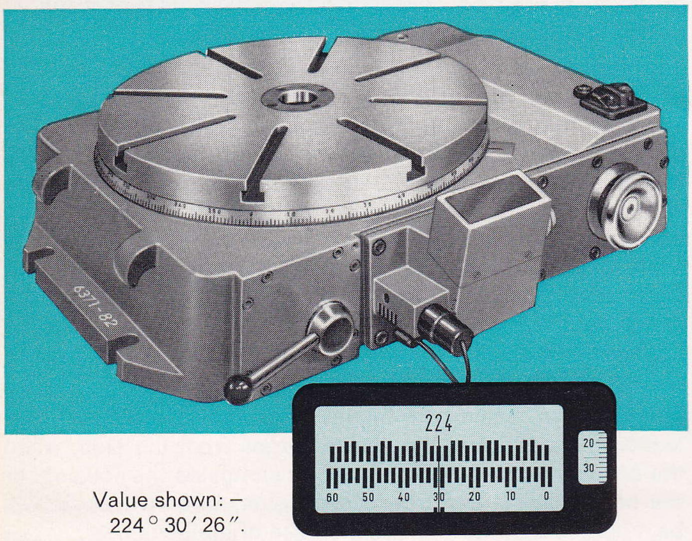
## Description

The Leitz optical installation consists of prefabricated structural units which — preferably after previous planning — are installed according to the position and construction of the machine.

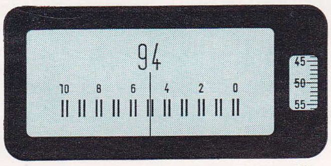
The millimetre division and the figures on the glass scale are illuminated by transmitted light; reversal system (produced with varying optical equipment for the required deflection of the beam) and mirror project scale divisions figures onto the groundglass screen of the reading device (projection reading). Reading is simple due to the prominent arrangement of the device: — after the symmetrical setting of the full mm-line, of which a clear and contrasty image is formed on the groundglass screen, the intermediate values can be read directly in a projection window; all further calculations are superfluous. As the illustration on the left shows, the reading device is also suitable, with a special scale, for angle readings and -settings of built-in graduated circles.

It is recommended to contact us in advance in order to ensure that scales and optical installations are mounted in the most suitable position for measurements either in a newly designed or an overhauled machine. Drawings of components directly related to the installation of the optical system will give us information about the space available, so that detailed consultation will be possible. Any drawings sent to us will of course be treated in strict confidence.

Rotating stage
with LEITZ optics for angle measurements.



Value shown: – 224° 30′ 26″.



Scale picture of the optical installation for linear measurements; value shown: – 94.550 mm.

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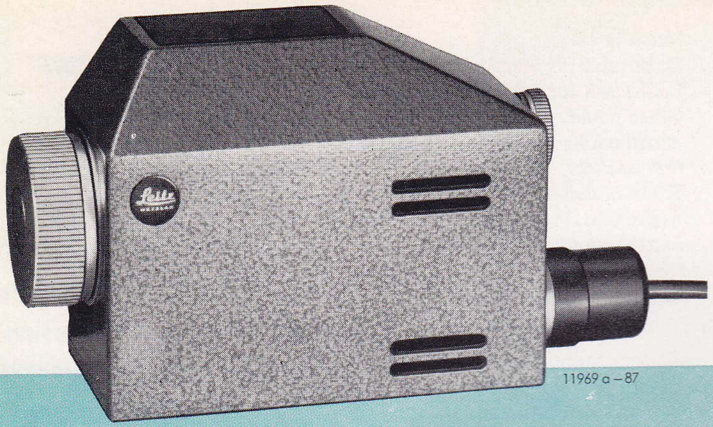
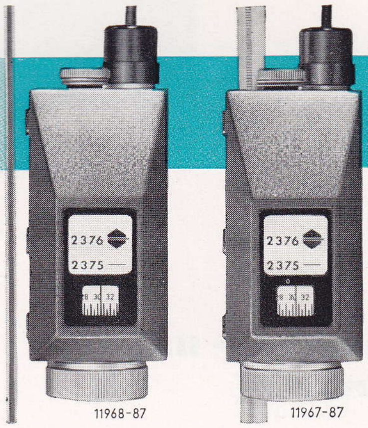
WETZLAR



# Scale projection device MP



Scale projection device MP 5; value shown: 2376, 305 mm
left: Lateral beam
right: Bottom beam

### Technical data

| Projection device | MP 5 | MP 10 | MPz 2 | MPz 5 |
|---|---|---|---|---|
| Magnification 12 x | | | | |
| Scale unit | 5 $\mu$m | 10 $\mu$m | 0.0002″ | 0.0005″ |

| | | |
|---|---|---|
| Scale | H-profile, 6 x 16 mm | 0.24 x 0.63″ |
| Material | stainless steel | |
| Expansion coefficient $\alpha_{20}$ | $10.5 \times 10^{-6}$ / °C | |
| Maximum division length of a single scale * | 1200 mm | 47″ |
| Division length of single scale with combined scale lengths | 1000 mm | 40″ |
| Numbered scale division | 1 mm | 0.05″ |
| Maximum aggregate scale error | < DIN 864 | |

* Shorter scales on request

### Application

Optical attachment for setting and reading machine positions.

### Description

The LEITZ scale projection device has a slim housing which takes up little space. This compactness and the many ways in which it may be fitted make it possible to attach this device to almost any existing machine.

The optical elements of the projection device project the scale division, illuminated by incident light, on a ground-glass screen with a setting mark, on which it is aligned symmetrically by turning a large knurled knob. A drum scale appears magnified in the same window next to the groundglass screen with which it is connected; this allows reading fractions of a millimeter or inch. The projection device can be fitted with a so-called zero setting in order to start from a whole mm value during the adjustment. After the drum scale has been set to zero or a whole starting value, it is possible to set the scale division opposite the mark independently of the ground-glass screen displacement.

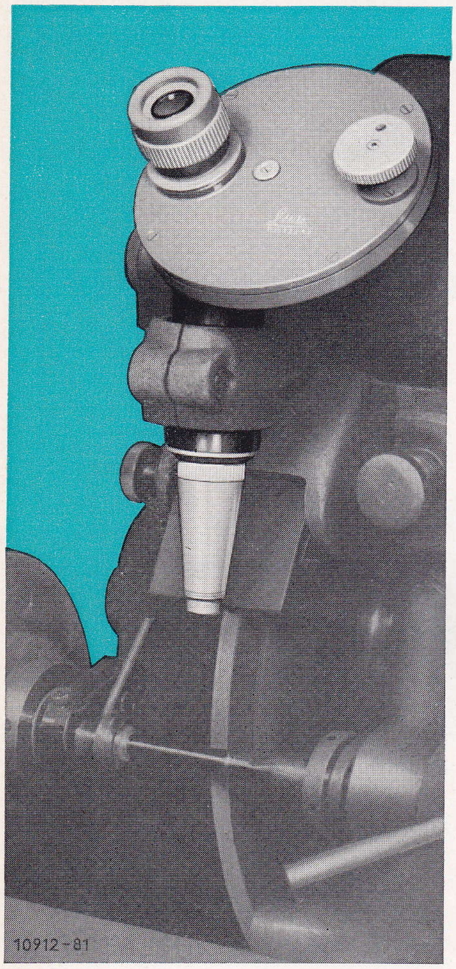
There are two basic possibilities of arranging scale and projection device. Either the light emerges from the side, when the division area of the scale will lie alongside the housing, or the beam path is deflected downwards, when the scale will be mounted below or behind the base of the housing.

Its optical design permits the arrangement of the projection device at any angle of rotation around the axis of either the ray emerging from the side or of that emerging from the base. If the scale is mounted in the direction of movement the movement of the image in the projection window is not changed. This possibility of rotation is of advantage particularly with the scale mounted on the side, since it allows convenient viewing even when the projection device had to be mounted at some distance from the operator for structural reasons.

A 6 v 15 W low-voltage lamp is used for illumination, with a timing switch for limiting its operation.

Detailed description: — List 87—1.

# Machine tool microscope



### Technical data

| | | | |
|---|---|---|---|
| Magnification | 10 x | 20 x | 30 x |
| Object field diameter | 20 mm 0.79″ | 10 mm 0.39″ | 6,5 mm 0.26″ |
| Aperture | 0.065 | 0.075 | 0.09 |
| Working distance | 100* mm 4″* | 75 mm 3″ | 58 mm 2.3″ |
| Clamping diameter | $38_{h6}$ mm | | |
| Weight | approx. 1.2 kg 2.6 lbs. | | |

* Objectives for 10x total magnification available also with 152, 190, and 235 mm working distances. These objectives have an aperture of 0.045.

### Description

The machine tool microscope can be directly attached to machine tools or other fixtures. The tube may be mounted horizontally, vertically, or at any other angle. Various models of this instrument are available. Tube, illuminating device, objective and eyepiece can be combined individually according to requirements. The standard model includes a microscope tube with 45° viewing angle (on request fitted with rack-and-pinon movement), an eyepiece with thread profiles on a rotating graticule and a 3:1 objective for 30x total magnification.

The interchangeable eyepiece included in the standard equipment contains a revolving graticule with the conventional metric and Whitworth thread profiles; these are moved into the field of view by means of a fine adjustment for comparison with the workpiece. For special purposes an eyepiece with a graticule turret for 6 separate graticules (List 80–5) is available. A waterproof illuminating device for transmitted light and an illuminating device for incident light can be attached if desired.

Detailed description: — List 81–2.

### Examples of uses

For the attachment to machine tools, e.g. thread -cutting and -grinding machines, lathes, etc.; control of workpiece profiles on the machine by comparison with graticules; linear and angle measurements with screw micrometer eyepiece (p. 25) and goniometer eyepiece.

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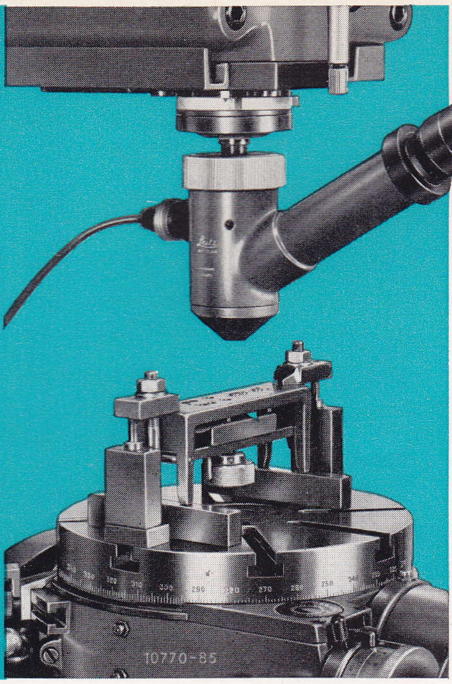
# Centring microscope



### Technical data

| | | |
|---|---|---|
| Magnification | 30 x | |
| Object field diameter | 6.5 mm | 0.26″ |
| Aperture | 0.09 | |
| Working distance | approx. 60 mm | 2.4″ |
| Suitable for | | |
| Morse's taper | 2, 3, 4, 5 | |
| ISA steep-angle taper | 30, 40 | |
| cylindrical shaft | $^1/_2$ ″ | |
| Weight | approx. 1 kg | 2.2 lbs. |

### Examples of uses

Centring of rotating stages on machine tools; setting of marked working surfaces, coordinate points, bores, centers; adjustment of circular scales and centring circles.

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WETZLAR

### Description

After the process of alignment which can be carried out in a comfortable position due to the inclination of the microscope tube the instrument can be interchanged in a single operation with drills or milling cutters, so that the machine is ready for the subsequent operation.

The centring microscope has a correction mount, hence the built-in graticule with cross lines can be focused for any eye. In addition to this graticule one with concentric circles can be built in.

The built-in incident-light source illuminates the workpiece perfectly.

A setting angle which permits the exact centring of round or strongly bevelled edges of workpieces is available.

Detailed description: – List 85–4.

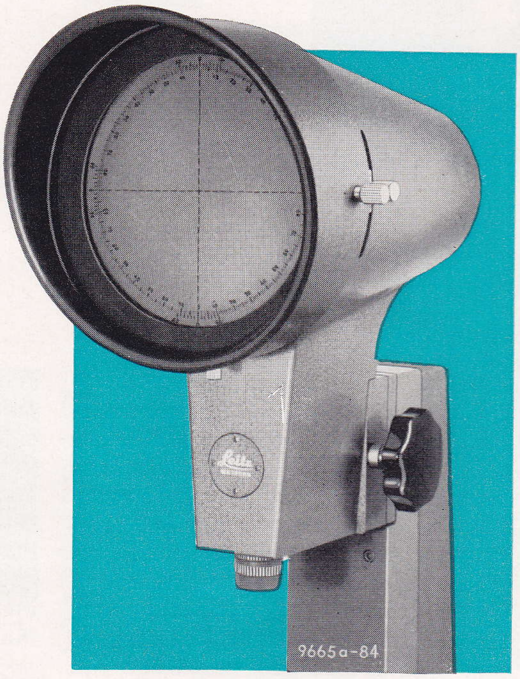
### Examples of uses

For profile control
by means of projection
on machine tools,
especially on backing-off lathes,
profile grinding machines,
die sinkers and punch grinders.

### Technical data

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Projection screen diameter | | 200 mm | 8″ | | | | | | |
| Reproduction ratio (interchangeable) | | 10:1 | | 20:1 | | 30:1 | | 50:1 | |
| Object field diameter | | 19 mm | 0.75″ | 9.5 mm | 0.37″ | 6.3 mm | 0.25″ | 3.8 mm | 0.15″ |
| Working distance | | 96 mm | 3.8″ | 75 mm | 3″ | 75 mm | 3″ | 55 mm | 2.2″ |
| Weight | approx. | 13 kg | 29 lbs. | | | | | | |

## Machine projector



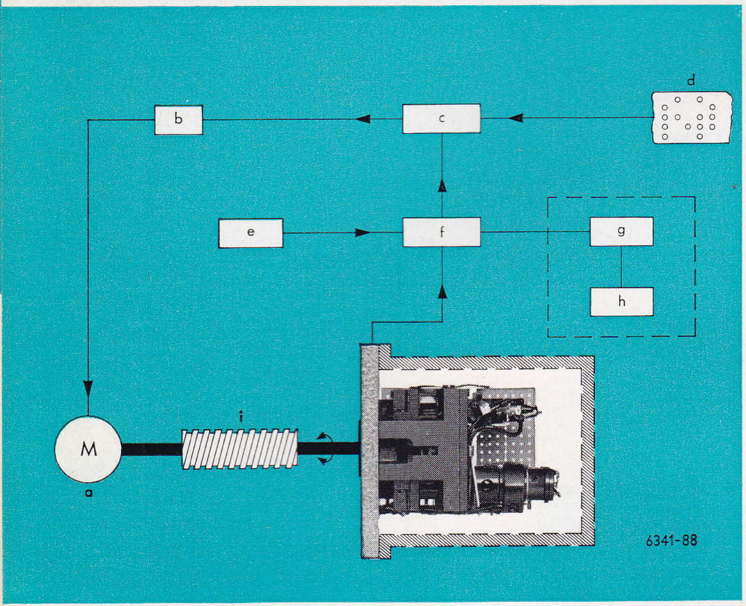
### Description

The machine projector, with upright and right-way-round image, offers the possibility of observing workpiece and tool together on the projection screen. This considerably simplifies machine operation. Machine vibrations do not affect the instrument adversely.

A transmitted-light device, protected against water spray, guarantees an evenly illuminated projection image easily seen even under daylight conditions. It is available in various models in order to suit the illumination to individual conditions of space.

The projection screen, which has a circular scale and cross lines, can be rotated. Profile drawings can be mounted in order to compare shapes.

# Photo-electric incremental angle transducer



Block wiring diagram of a digital control circuit for the punched-tape operated setting of a machine tool with logical-flow feed-back through the photo-electric incremental angle transducer

a Servo motor
b Servo amplifier
c storage unit (rated/real value comparison)
d Input, punched tape programme
e Coordinate zero setting
f Reversible counter
g Position indicator
h Number printer
i Lead screw

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WETZLAR

**Description**

The angle transducer converts mechanical rotary motion into periodic variations of light flux, and these into electrical current variations. If two signals are used these can be processed in the correct sense of rotation by means of a reversible counter with 1, 2, or 4 counting steps per period. Determination of the difference between the photoelectric currents, flowing, say, according to the functions

$$I_a = \frac{a_0}{2} + \frac{1}{2} a_0 \sin n \alpha$$

or $$I_b = \frac{b_0}{2} + \frac{1}{2} b_0 \cos n \alpha$$

respectively

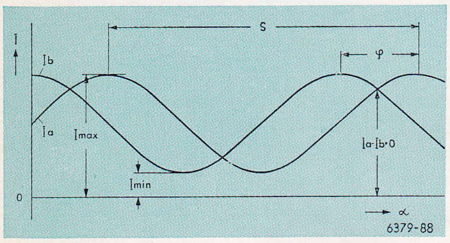
makes it possible to lay down angle positions of full angle increments for the values $I_a - I_b = 0$ with small measuring tolerances. These properties are produced by the new optical principle: — Diametrically opposed points of a radial grid disc moving on precision ball bearings are superimposed by an optical system forming their same-size image. The images move in the opposite direction to the scale divisions. The image is split by a bi-refringent prism into two part-images displaced through $^1/_4$ ($^1/_2$) division period and polarized vertically to each other. After modulation on the graduated disc the part-light-fluxes corresponding with the part-images are separated by the prism according to the directions of polarization and passed on to the silicon receivers which are practically insensitive to temperature variations.

The countermovement of image and graduated disc doubles the number of signal periods opposite the division period number of the graduated disc, and optically compensates the errors caused by the eccentricity of the graduated disc. Due to the double use, based on polarization phenomena, of the light flux in the same beam section the ratio of $I_a$ and $I_b$ depends on the angle position only, while lamp variations have no effect. By averaging a large number of divisions it is possible to obtain small measuring tolerances with this small instrument (45 mm (1.8″) mean division diameter). Interchangeable plug-in components in the transmitter permit the mounting of any adapter amplifiers on the plug plates with printed circuits.

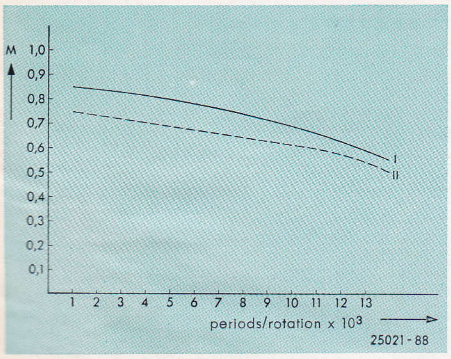
Detailed description: — List 88—2.

## Examples of uses

Logical flow feedback with stored-programme machines; digital speed and position control; measurement of signs and values of angles and angular velocities; harmonic analysis of transmission and gear faults; installation in measuring instruments such as torsion balances; control of digital data storage equipment (punched tape, cards, printers, magnetic tape).



Signal pattern at the transmitting end of the incremental angle transducer.



Degree of modulation as function of the number of signal periods per rotation.
I mean degree of modulation achieved
II lower limit of acceptance

## Technical data

Signal periods per rotation: - choice of
1000, 2000, 3600, 4000, 4320, 7854, 10 000, 10 800, 12 800

Degree of modulation $M = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

Lamp: – D. C. voltage 1.5 – 3 v; 1.2 – 4.5 W according to the signal amplitude required; standard value 2.4 v 2 W.

| | |
|---|---|
| Radiation receiver<br>choice of a, b * | a<br>silicon photo-duodiode |
| $U_{b\,max}$<br>(maximum supply voltage) | 20 v d. c.<br>or a. c. 20 v peak |
| Drop<br>from modulation factor | 3 dB at 40 – 80 kc/sec.<br>light frequency |
| Signal amplitude referred to 2.4 v lamp voltage | |
| with 2 signals | min 0.2 mA (mean 0.3 mA) |
| with 1 signal | min 0.5 mA (mean 0.7 mA) |
| Effect of temperature on the light flux | approx. + 0.7 %/°C |

* b for higher light frequencies; information on request after completion of the design stage of this instrument.

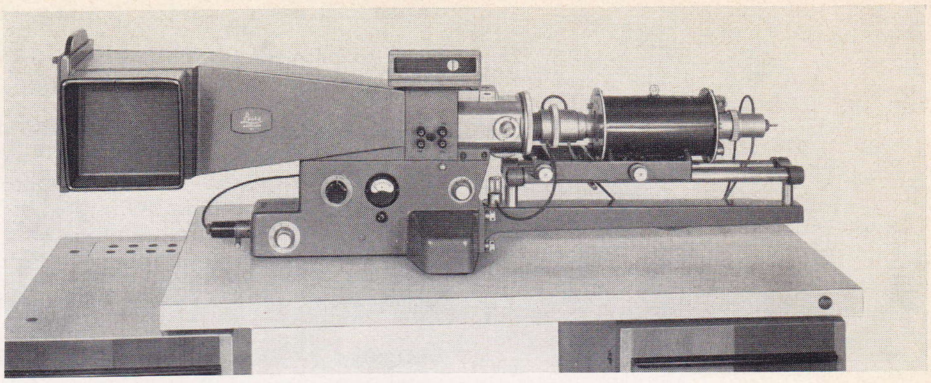
Initial signals
two interlinked signals $I_a$, $I_b$ (if desired also a signal $I_o$ with a receiver)
Choice of phase angles 90°, 120°, 180° (within ± 5° to ± 10°)
Maximum deviation of the angle increments from the nominal position
(determined by $I_a - I_b = 0$) according to division max. 2.5 sec. to max. 15 sec.

Moment of inertia approx. 60 gcm² (possibly special model with reduced moment of inertia)

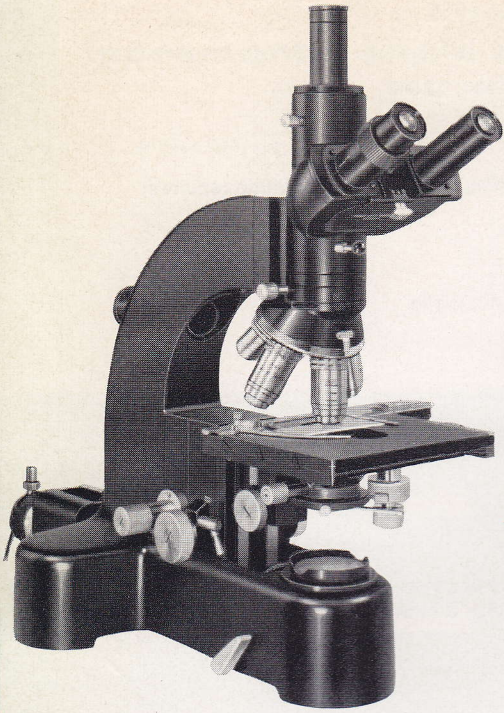
Moment of friction (without simmer gasket)

| | |
|---|---|
| Repose friction | 4 gcm (standard value) |
| Rotational friction | 2.5 gcm (standard value) |

Mechanically admissible number of rotations 10 000 r. p. m.
(unless limited by frequency limit of the receivers with fine divisions).



Universal Dilatometer
Model UBD



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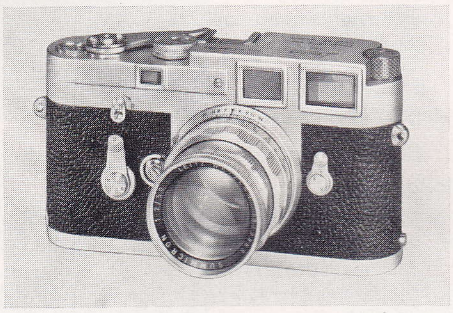
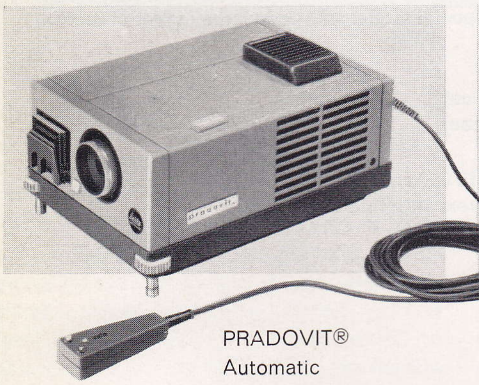
◀ Large Research Microscope
ORTHOLUX®

LEICA® miniature camera
Model M 3

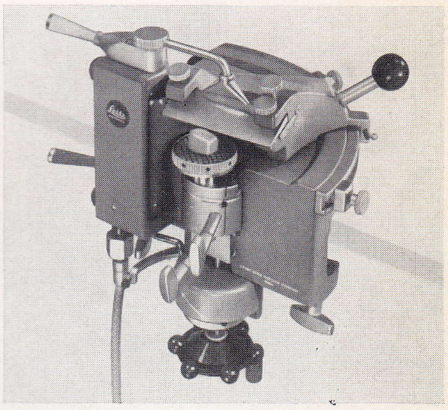


TRINOVID®
a new type
of prism binoculars



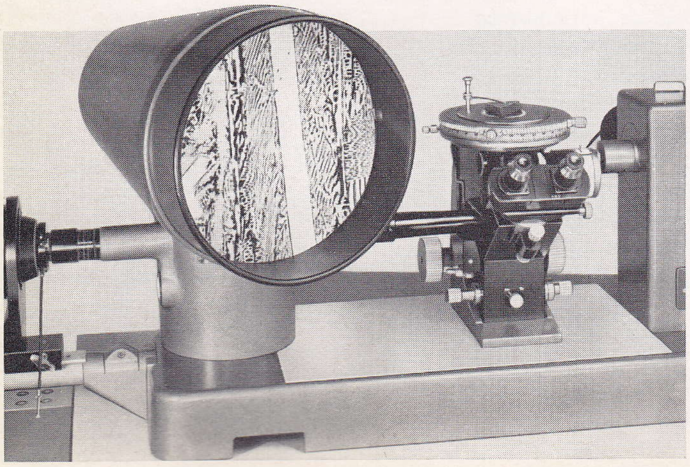
PRADOVIT®
Automatic
slide projector

LEICINA®
the fully automatic
precision 8 mm
motion-picture camera

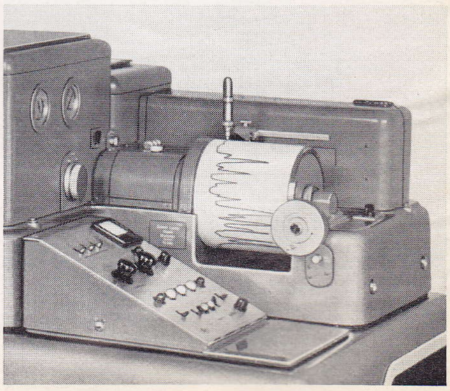


Large
Freezing Microtome

Large
Metallographic
Microscope MM 5



Infrared Spectrograph
equipped for the visible
and UV spectral regions



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